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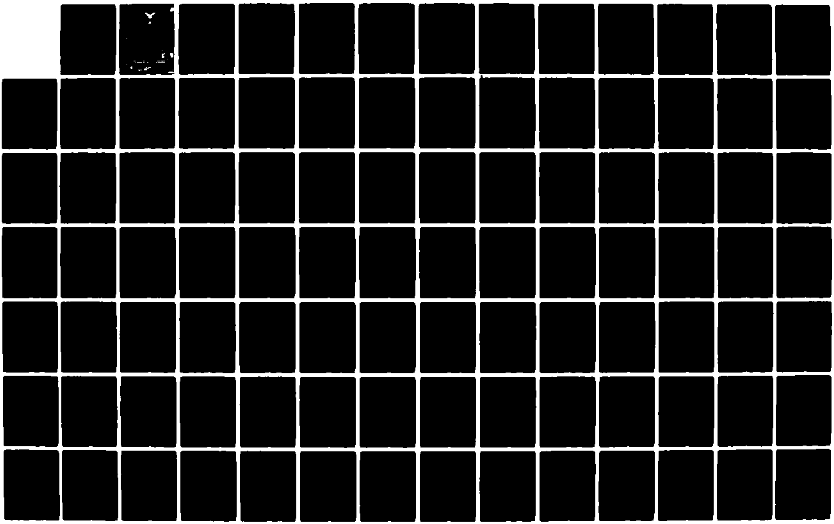

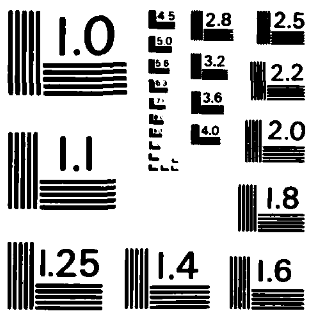

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A SIMULATION STUDY of THE COEFFICIENT OF VARIATION AS A MEASURE OF VARIABILITY OF REQUIREMENTS IN A MATERIAL REQUIREMENTS PLANNING ENVIRONMENT

by

Peter B. Bobko

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by

PETER B. BOBKO

A Dissertation Submitted

in Partial Fulfillment of the Requirements

for the Degree of Doctor of Business Administration

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Chairman: Professor Thomas E. Vollmann

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GRADUATE SCHOOL OF BUSINESS

1983

ACCEPTANCE

This dissertation has been accepted in partial fulfillment of the requirements for the Degree of Doctor of Business Administration in the Graduate School of Business of Indiana University.

Date April 15, 1983

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William Lee Berry

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PREFACE

I would like to express my deep appreciation and graditude to the following individuals who made this research effort a reality. Professor Thomas E. Vollmann, as my major advisor, helped immensely early in formulating this project and then provided continued encouragement and support as the project was further refined. Professor D. Clay Whybark who was constantly available for consultation and focusing. Professor A. Victor Cabot whose intense interest, perception and technical advice were invaluable. Professor William L. Berry for his continued direction, guidance and support. And finally, but most important of all, to my wife and sons for providing the encouragement, patience and love that made it all possible.

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ABSTRACT

Bobko, Peter B. D.B.A. Indiana University, April 1983. A Simulation Study of The Coefficient of Variation as a Measure of Variability of Requirements in a Material Requirements Planning Envirohment. Major Professor: Thomas E. Vollmann.

The management of production inventories is a concern of production and operations managers. Among the decisions a manager must make is the selection of a procedure to determine the timing and size of replenishment orders. The selection of a procedure, in turn, is dependent upon the environment in which it will be applied. The research described in this dissertation is concerned with the adequacy of the coefficient of variation as a descriptor of a requirements vector in the selection of a lot sizing procedure within a Material Requirements Planning (MRP) environment.

To study the coefficient of variation, the characteristics of a requirements vector which contribute to "lumpiness" are described and defined. These characteristics are then modeled into requirements vectors developed using three different dynamic generation procedures. A computer simulation program implements MRP logic and determines total inventory cost for these vectors using a selected group of lot-sizing procedures.

Analysis of variance was used to analyze the results of the simulations using relative total inventory cost as the criterion. Relative total inventory cost is defined as the percentage deviation of a selected lot-sizing procedure from a base (Groff) procedure.

A finding of this research is that while the method used to generate requirements vectors and the grouping patterns of those vectors are significant factors when evaluating lot-sizing procedures, they do not change the conclusions reached using only the coefficient of variation.

INTRODUCTION

Inventory exists in all phases of a business. In the manufacturing segment it serves to uncouple suscessive operations in the making of a product. In the marketing portion of the business it uncouples the process of making a product from meeting the independent demands of customers for a finished product [58]. The investment in inventory may be substantial. Depending on the firm itself and the type industry, inventory may constitute from 25 to 75 percent of the firm's current assets [64]. On a national scale, the magnitude of this investment may be seen in the Survey of Current Business statistics published by the U.S. Department of Commerce and presented in Figure 1. The ratios in that figure serve to illustrate two points. The first is the relative magnitude of inventory to sales in all manufacturing industries. The second is the accounting classification of the types of inventory which, though somewhat arbitrary, does indicate the relative importance of inventory in the manufacturing process.

GENERAL BUSINESS INDICATORS

BUSINESS SALES	1978	1979	1980
Manufacturing total (mil$)			
Durable goods industries	798,057	909,631	936,030
Nondurable goods	698,515	817,660	909,906
BUSINESS INVENTORY-SALES			
Manufacturing total (ratios)			
Durable goods industries	1.84	1.98	2.16
Materials and Supplies	.60	.65	.70
Work in progress	.77	.85	.96
Finished goods	.47	.48	.50
Nondurable goods industries	1.14	1.12	1.13
Materials and Supplies	.44	.46	.46
Work in progress	.18	.18	.18
Finished goods	.52	.47	.48

Figure 1.1

(Source: Survey of Current Business, Department of Commerce, 1981)

Manufacturing Inventories

Manufacturing inventories may be considered as those carried as work in progress and materials and supplies. These accounting classifications do not contribute much to an inventory manager's questions about the proper levels of inventory to meet his manufacturing objectives but they are convenient for "scorekeeping" and they do provide a relative measure of magnitude. As illustrated in Figure 1, the two classifications account for over half the total inventory of a manufacturing firm. It is reasonable, since inventory represents such a large capital investment for a firm, that policies which influence the level of inventory receive considerable attention. Recognition of the impact inventory has on the capital requirements and profitability of a firm is indicated by a new word in the vocabulary of inventory managers.

> "Kanban is the word for Japanese auto manufacturers' precise methods of controlling inventories so that suppliers deliver needed parts to the assembly line 'just in time'. Holding inventories of engines, axles and other parts to an absolute minimum saves Japanese auto makers hundreds of dollars per car in storage and carrying costs."
>
> It is estimated "... that it costs General Motors Corporation well over $3 billion a year to carry its approximately $9 billion in world-wide inventories. The cost includes storage, handling,

> staffing, freight charges and losses due to obsolesence, defects and tying up of inventory funds that otherwise could be earning a profitable return" [54].

The first step in delivering the right items to the production line "just in time", is to know how much of what item will be needed when. A managerial approach for providing this information in a timely manner is Material Requirements Planning (MRP). Given that a manager has such knowledge of the timing and quantity requirements for an item, he is still faced with the conflicting objectives of minimizing purchase or production cost, minimizing inventory investment, minimizing storage and distribution cost and maximizing service level [58].

One decison an inventory manager must make is which available procedure should be used to determine the timing and size of replenishment orders. The selection of a procedure, in turn, is dependent on the environment in which it will be applied. As described in chapter II, the demands in a manufacturing environment for an item, used as a component part of another item, are not usually of the same size and frequency each period. Instead, the demands occur at varying time intervals and for varying quantities of the item. This variability of the demand sequence has been referred to as "lumpiness" [10,12,95]. A convenient, frequently used measure of this lumpiness is the coefficient of variation (Cv), the ratio of standard deviation to mean [7,48,61,95,97].

Concern of this Research

This research addresses the sufficiency of the coefficient of variation as a measure of the "lumpiness" of a requirements vector in the evaluation of ordering procedures commonly used in a manufacturing environment. Thus it is concerned the selection of a procedure to determine order size and timing in a manufactuing environment by an inventory manager. Of additional interest is the appropriate characterization of requirements information by identifying those elements which are important in evaluating ordering procedures.

OVERVIEW

This chapter has provided a brief perspective of the general nature of this research. Chapter II will develop in detail the terminology and conceptual model used in this research. The research objectives will then be more definitvely specified. Chapter III will review the literature related to lot sizing algorithms and "lumpiness" in an MRP environment. Chapter IV develops the methodology of the research and makes the transition from the conceptual, structual model of the problem to the simulation model used in the experiments. The experimental factors and analysis of results are presented in chapter V.

Chapter VI contains the conclusions reached from the

experiments with the model and from the morphology of developing the characterization of a requirements vector for the evaluation of lot sizing algorithms. In addition the contributions of this research and areas to which it may be extended will be presented.

CHAPTER II

THE General Lot Sizing Problem for Discrete Time Phased Requirements

The Management of production inventories represents an area of considerable concern to production and operations managers. As presented in the preceeding chapter, these inventories may represent a considerable portion of the firms assets. Effective control of these inventories can result in cost savings. The study described in this dissertation will investigate the use of the coefficient of variation as a sole measure of "lumpiness" in the characterization of a requirements vector. The environment in which the representation of a requirements vector becomes important, is in the selection of a procedure to determining the lot size and and timing for components used in a requirements planning system.

The objective of this chapter is to provide a framework for the study. Initially the basic concept of MRP will be introduced and compared to a traditional order point system. Next, the classic assumption of continuous demand will be relaxed to include the discrete nature of requirements in the production environment. A brief overview of the logic of the ordering function of an MRP system is provided. The

production environment introduces the presence of "lumpiness" in a requirements vector, which is illustrated through several examples. A working definition of lumpiness is developed in terms of the elements which contribute to that lumpiness and which may influence the selection of a procedure to be used to determine the magnitude and timing of planned orders. Finally, once this framework has been established, we will define the problem of using the coefficient of variation, as a solitary measure of lumpiness in a requirements vector, when evaluating discrete lot sizing procedures.

Traditional Inventory Ordering Systems

Traditional inventory replenishment systems are based on a statistical analysis of historic patterns. The underlying assumption of this type of ordering system is that the demand for an item is not known and must be forecast. In the normal functioning of the system, the placement of an order is considered either at some review point in time, or at a predetermined level of inventory. In the periodic review system, the level of inventory is examined at the end of some time period, and if necessary, an order is placed to bring the inventory up to an established maximum level. In an order point system, when the level of inventory reaches an established "order point", an order of predetermined size is released. The orientation

of these traditional systems is retrospective.

Material Requirements Planning

Material Requirements Planning is a computer-based inventory management system which provides, as one of its outputs, a mapping of the demands for a parent product into the requirements for its component elements. The underlying assumption is that if the components of a parent item are uniquely and explicitly defined, then the component requirements to make the parent item represent dependent demand and may be computed directly. The parent item may be a final finished product; a major assembly; or itself a component. The mapping of a parent item into its components is termed an "explosion". The explosion translates scheduled production requirements into net component requirements, to insure the availability of components needed to implement the production schedule. Under perfect conditions, the MRP system would release orders for component parts with the correct lead time, and in the proper amounts so that production of parent items could proceed as scheduled, at minimum cost and with no excess inventory. To fix terminology, this process is illustrated in figure 2.1, 2.2 and 2.3.

The Product structure of item "A" is graphically depicted in figure 2.1. The nodes represent items which may be both the parent to lower level components and the

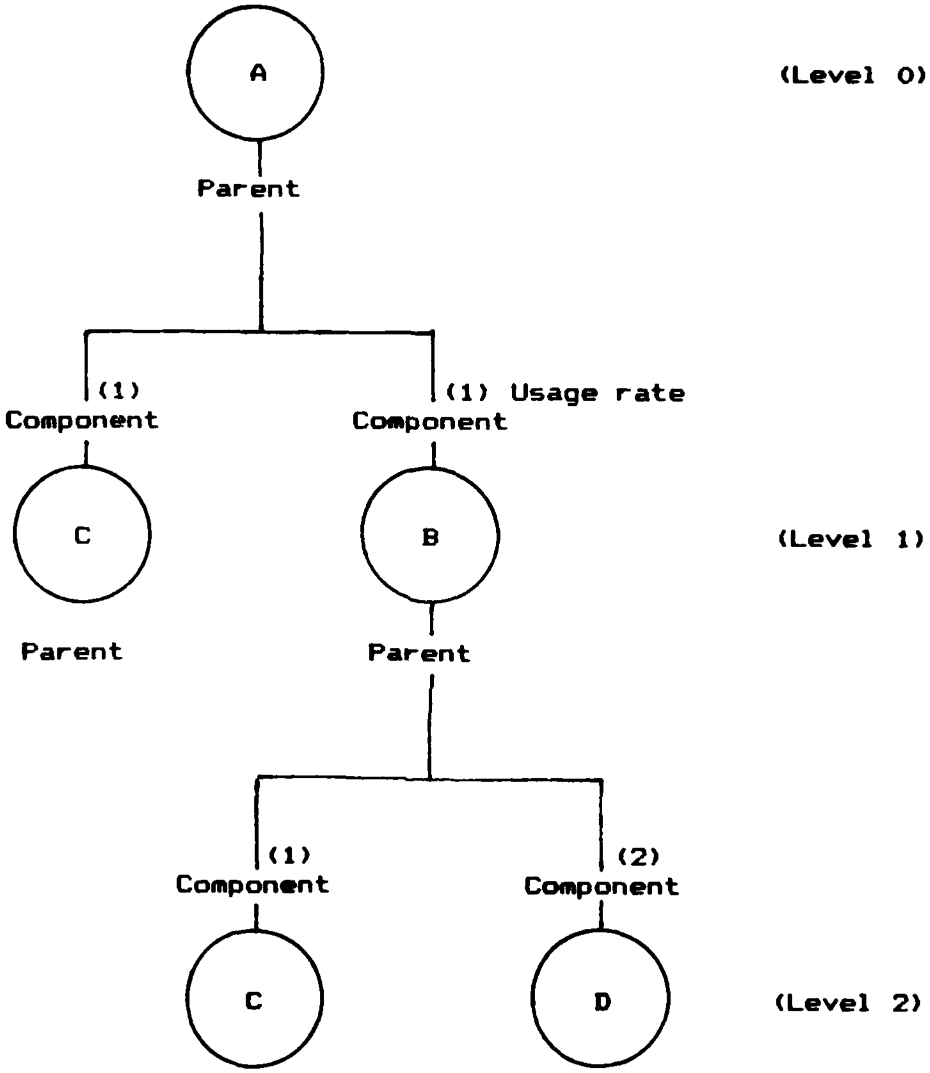


Figure 2.1 --- Product Structure of Item "A"

component of a higher level item. As illustrated, product "A" is assembled from one unit each of components "B" and "C". Component "B", in turn, is the parent of components "C" and "D". The numbers in parenthesis on the lines joining the nodes represent the usage rate of the component in the parent item. A lead time of one period is assumed for all items. To assemble "A" requires one period and components "B" and "C" must be available at the beginning of the assembly period. The hierarchial relationship of the components is indicated by the level of each component. Higher level components are indicated by small numeric values. Product "A", at the highest level , has a value of "0", while component "C", at the lowest level, has a value of 2.

Item	period	1	2	3	4
A	Gross requirements				5
B	Gross requirements			5	
C	Gross requirements		5	5	
D	Gross requirements		10		

Figure 2.2 --- Gross Requirements Offset for Lead Time

The gross requirements for the components required to produce "A", unadjusted for available inventory as defined below, are shown in figure 2.2. The requirement of 5 units of item "A" in week 4 is mapped into a requirement for 5 units each of components "B" and "C". Offset for the 1 week lead time, these components must be available in week 3. In a similar manner, the requirement for item "B" results in a requirement for 5 units of component "C" in week 2. The usage rate of 2 units of item "D" for each unit of item "B" results in a requirement for 10 units of "D" in week 2.

period		1	2	3	4
Gross requirements				5	
Scheduled receipts				2	
On hand	(2)	2	2	2	0
Net Requirements				1	

Figure 2.3 -- Net Requirements Calculation for Item "B"

The process of subtracting available inventory from gross requirements for an item is known as netting. Consider component "B" in figure 2.3. From figure 2.2, a

gross requirement for 5 units of "B" exists in period 3. Two units previously ordered are scheduled to arrive (scheduled receipts) in period 3. In addition, 2 units are in inventory at the beginning of period 1, as indicated by "(2)" in the on hand balance row. The net requirement in period 3 is calculated as the gross requirement less scheduled receipts, less the on hand balance. The net requirement for "B" in period 3 is 1. A negative net requirement would be interpreted as a zero net requirement [70].

period		1	2	3	4	5	6	7	8	9
Gross requirements				5				3		
Scheduled receipts				2						
On hand	(2)	2	2	2	0	0	0	0	0	0
Net Requirements		0	0	1	0	0	0	3	0	0

Figure 2.4 --- Nine Period Net Requirements Calculation for Item "B"

The process of determining net requirements may be extended to a planning horizon for which estimates of gross requirements are available and net requirements are to be

determined. In figure 2.4, the net requirements calculation for item "B" is extended to 9 periods and includes the additional gross requirement for 3 units in period 7. Since there is no available inventory, a net requirement for 3 units occurs in period 7. The net requirements for item "B" for the 9 period horizon my be represented by the requirements vector:

(0, 0, 1, 0, 0, 0, 3, 0, 0)

At a point in time, preceeding the first net requirement, at least one order must be planned to cover net requirements. This planned order may include more than one of the net requirements. When the planned order is released to the shop or a vendor, it becomes an open order or scheduled receipt. For the product structure of item "B", the order will become the gross requirements for items "C" and "D".

The General Lot Sizing Problem

The general lot sizing problem, in an MRP environment, is to combine individual period net requirements for an item into planned orders. The procedure used to determine the lot size and timing of a planned order is referred to as the lot sizing procedure. In the MRP environment, the orders for replenishment quantities must be specified at discrete points in time. The criteria normally applied to the

selection of the procedure is the minimization of inventory related costs and meeting requirements each period. Inventory related costs are usually the sum of setup and holding costs although recent research has included consideration of purchase quantity discounts [7,8,9,22,29,39,97].

A lot sizing technique, which is common to traditional order point systems and some MRP systems, is the Economic Order Quantity (EOQ) [10,91]. Used in an order point system, the decision rule is: order the EOQ when the level of inventory reaches a predetermined order point. Applied to an MRP system, the EOQ is ordered, with adequate lead time, to cover a net requirement. The calculation of the EOQ and total average minimum cost for a continuous demand stream is demonstrated in figure 2.5.

In contrast to the traditional ordering systems, the orientation of an MRP system is toward the future as defined by the production schedule. The assumption of continuous small demands in the traditional policies become the discrete "lumpy" gross and net requirements of an MRP system, illustrated in figure 2.4. The differences in the continuity assumption is highlighted in figures 2.6 and 2.7. Figure 2.6 presents independent demand which is fairly uniform and occurs in relatively small increments compared to the replenishment quantity [70]. Given that demand is assumed constant and equal to 1 unit during lead time; when

---

$$EOQ = \sqrt{\frac{(2)(D)(Co)}{(Ch)}}$$

where EOQ = Economic Order Quantity
Co = Setup cost
$25
Ch = Holding cost/annual/unit
$20
D = Annual demand
10 unit

$$TC = \sqrt{(2)(D)(Co)(Ch)}$$

$$= 100$$

where TC = Average annual total cost

Figure 2.5 --- Calculation of EOQ and Average Annual Total Cost for Continuous Demand

---

the level of inventory reaches the order point of 1 unit, a new order is released. That order arrives as the inventory reaches the zero point, and the cycle starts once again. In figure 2.6, an order has been placed which arrives at the beginning of period 1. Figure 2.7 presents the same order point system applied to demands which occur at discrete points in time.

Requirements in an MRP environment are usually

period	1	2	3	4	5	6	7	8	9
requirement	1	1	1	1	1	1	1	1	1
planned order release					5				
beginning inventory	5	4	3	2	1	5	4	3	2
ending inventory	4	3	2	1	0	4	3	2	1

carrying cost = \$ 2/unit/period
setup cost = \$25/order

setup costs	\$50
carrying costs	49
total costs	\$ 99

Figure 2.6 --- Order Point Procedure for "Fairly" Uniform independent Demand Stream

discontinuous and lumpy [97]. Figure 2.7 shows both a requirements vector and a planned order release (order) vector. The requirements vector diverges from the continuity assumption and is considered lumpy. To meet these requirements, orders are released in the EOQ with sufficient lead time to arrive at the beginning of a net requirement period. The computation of the total ordering and holding cost for this policy are shown in figure 2.7 for

a 9 period time horizon, with a one period order replenishment lead time.

period	1	2	3	4	5	6	7	8	9
requirement	0	1	0	4	3	0	0	0	1
planned order release	5			5					
beginning inventory	0	5	4	4	5	2	2	2	2
ending inventory	0	4	4	0	2	2	2	2	1

carrying cost = \$ 2/unit/period
setup cost = \$25/order

setup costs	\$50
carrying costs	43
total costs	\$ 93

Figure 2.7 --- Computing Total Cost

Forecast Requirements

The orientation of an MRP system is towards the future as defined by forecast requirements. These requirements provide the information input to the procedure used to size and release orders. The release of orders, in turn, serves

to link the planning and execution phases of the inventory and production process. Given that forecast requirements are perfect, in general there would still be a lumpiness in those requirements from period to period.

Lumpiness in the Requirements Vector

Lumpiness in the requirements vector has been the subject of research directed to relating the degree of lumpiness to the cost performance of common lot sizing techniques [10,48,95]. The "lumpiness" or fluctuation of a requirements vector has also been referred to as variability [10,34,97]. This study will expand on previous research in this area.

Lumpiness in the gross requirements for a part at the component level is dependent upon: lumpiness in the gross requirements for the parent item in which the part is a component; the usage factor of the component in the parent item; the lot sizing technique used at higher levels; and the commonality of the part to several higher level components. Each of these sources of lumpiness is discussed in the following paragraphs.

The lumpiness of a parent item will be reflected in the requirements for its component elements. If a one to one relationship exists between a parent and its component part, and net requirements are individually ordered, then the

relationship between the net requirements of the parent and the gross requirements of the component is direct. This relationship is depicted in figure 2.1 for parent item "A" and component item "B". If the component part is common to more than one higher level item, however, the impact of the lumpiness of one parent item may be either offset or increased by the lumpiness of another. Component "G" in figure 2.8a is a component of parent items "E" and "F", both of which have the same, every other period, requirement for 100 units. Because the requirements occur in alternating periods, the vector sum of the requirements results in a uniform requirement of 100 units each period for "G". The same factors apply in figure 2.8b except the requirements for "E" and "F*" occur in the same periods. The resulting vector sum, "G*" has larger requirements which occur every other period. At the extremes, an item which is unique to a single parent would reflect the variability of that parent and may have discrete "lumpy" requirements while an component, common to a great number of parents, may have an essentially smooth pattern.

The usage rate of a component will influence its lumpiness. Components "C" and "D" in figure 2.1 are used in parent item "B". Because of the usage rate of 2, the net requirements of item "B" are doubled to become the gross requirement for item "D".

The lot sizing technique used at higher levels in the

period	1	2	3	4	5	6	7	8	9
net requirement "E"	100		100		100		100		100
net requirement "F"		100		100		100		100	
gross requirement "G"	100	100	100	100	100	100	100	100	100

2.8a

period	1	2	3	4	5	6	7	8	9
net requirement "E"	100		100		100		100		100
net requirement "F*"	100		100		100		100		100
gross requirement "G*"	200		200		200		200		200

2.8b

Figure 2.8 -- Lumpiness of a Component Resulting From Multiple Parents

product hierarchy will influence the variability of gross requirements at lower levels. If the ordering procedure used at the next higher level released an order for each individual net requirement, then these requirements, adjusted for the usage rate, become the gross requirements for the component part. Given that the requirements are constant, there would be no variability. If the ordering

procedure used at the higher level combined net requirements for release in larger, less frequent batches, then the variability of the component part gross requirements would increase.

A Definition of Lumpiness

The measure of lumpiness for a requirement vector is viewed in terms of its ability to capture the characteristics which influence the total cost performance of lot sizing techniques used in an MRP timed phased record. Once the EOQ assumption of constant demand is relaxed, the operational considerations of dissimilar sized requirements and infrequent occurances must be addressed. Kaimann proposed the coefficient of variation (Cv) as a measure to "describe the variability of the demand situation" [48]. This measure is defined as the ratio of the standard deviation of the demand per period to the average demand per period. Although there is little question that this lumpiness of the demand stream is important, it has not been established that the coefficient of variation, is adequate as a solitary measure of variability when applied to an MRP environment [10,48,97].

To provide a common reference point, the following are considered elements of "lumpiness" for the discrete requirements of a MRP time phased record:

1. Frequency of Occurance. Over a given period of time, the number of actual occurances of a requirement may range from a single requirement to a requirement every period. The higher the frequency of requirements, the lower the lumpiness of the requirement vector.

2. Uniformity of Requirements. A requirements vector in which all occurances are of the same magnitude is less lumpy than a vector that has requirements of different magnitudes. The greater the variation in the requirements the more lumpy the vector. Individual requirements in occurance periods may range from a value of 1 to the total requirement for the time horizon.

3. Grouping of Requirements. If requirements occur less often than every period, but more than once over the time horizon, a grouping of requirements may be present. Periods of positive requirements could be interspersed with periods of no requirement. The more regular the grouping scheme, the less lumpy the requirement vector. Regularity of grouping is defined in the examples that follow.

In the context of this definition, the most lumpy requirement vector would occur if an entire time horizon's requirements were concentrated in a single period. At the other extreme, the least lumpy requirement vector would be represented by an equal distribution of requirements over every period. These elements of variability are illustrated in the following examples. In each example the average period requirement is 100 units.

The frequency of occurance factor is shown in figure 2.9. A requirement occurs 3 times in a 9 period horizon giving a frequency of 3/9. For this element of variability, it is immaterial in which 3 periods the requirements occur, or their magnitude.

period	1	2	3	4	5	6	7	8	9
Gross requirements	300		300			300			

Figure 2.9 -- Constant Gross Requirements with Occurance Frequency of 3/9 and Coefficient of Variation of 1.5.

Requirements which are not all the same magnitude are depicted in figure 2.10. The coefficient of variation is the same as in the previous figure but the frequency of occurance has increased and requirements are not uniform.

The concept of the grouping of requirements is presented in figure 2.11. In that figure, requirements are of the same magnitude and frequency as in figure 2.10. The relationship that has changed is the pattern of occurances within the time horizon. The grouping pattern may be described in two dimensions. The first is the regularity of the interval spacing between occurances, the other the periodicity of requirements. Regular interval spacing between requirements is seen in figure 2.11a. In that figure periods of null requirements and positive

period	1	2	3	4	5	6	7	8	9
Gross requirements	100		300		400			100	

Figure 2.10 -- Variation in Magnitude of Gross Requirements with Occurance Frequency of 4/9 and Coefficient of Variation of 1.5.

requirements alternate. In contrast, the spacing between requirements in figure 2.11b ranges from 1 period to 4 periods. Figure 2.11c shows requirements clustered in small sub groups which occur at intervals of approximately the same length. This last phenomenon of "clustered" requirements at regular intervals we will refer to as the periodicity of the requirements vector.

It is apparent that considerably different sequences of requirements can have the same coefficient of variation. The area of concern to an inventory manager is : can all requirement vectors with the same coefficient of variation be considered equivalent when evaluating lot sizing procedures in an MRP environment?

period	1	2	3	4	5	6	7	8	9
Gross requirements		100		300		400		100	

2.11a

period	1	2	3	4	5	6	7	8	9
Gross requirements	100	300		100					400

2.11b

period	1	2	3	4	5	6	7	8	9
Gross requirements		300	100			400	100		

2.11c

Figure 2.11 -- Grouped Gross Requirements with Occurance Frequency of 4/9 and Coefficient of Variation of 1.5.

Research Objectives

The overall objective of this study is to characterize a discrete requirements vector by identifying those elements which are important in evaluating lot sizing procedures used in an MRP environment. To accomplish this objective we will:

1. Extend and broaden the concept of lumpiness as measured by the coefficient of variation in the analysis of lot sizing procedures.

2. Develop a simulation model suitable for the evaluation of lot sizing procedures for variable requirements vector.

3. Evalute the performance of a few important common lot sizing procedures under specified representative conditions of variablitity .

4. Perform sensitivity analysis on those elements of the variability measure which have the largest impact on the cost performance of lot sizing procedures.

Summary

This chapter has provided a brief overview of logic of the ordering function in an MRP system. The concept of lumpiness in the MRP environment was decomposed into its composite elements and illustrated in examples. A working definition of lumpiness was developed in terms of the elements which contribute to that lumpiness and which may influence the selection of a procedure to be used to determine the lot size and timing of planned orders in that environment. In chapter III we will review the literature relating to lot sizing algorithms and lumpiness of requirements when evaluating lot sizing procedures in an MRP environment.

CHAPTER III

REVIEW OF THE LITERATURE

Chapter II introduced the problem of capturing the essential characteristics of a requirements vector, which influence the total cost performance of lot sizing techniques used in an MRP environment. A perspective for this research is established in this chapter by reviewing the literature related to the characterization of requirements vectors and to selected lot sizing procedures for discrete, single level, single item, requirements vectors.

The terms demand and requirements are used in the literature related to MRP topics. A distinction is that the term demand is properly associated with independent occurences while requirements relate to dependent occurences. As described in Chapter II, gross requirements for an item are derived from higher level parent items and generally exhibit lumpiness. In this research, we shall assume that the process by which higher level net requirements result in gross requirements may be adequately represented by demand generators common to the literature. As such, the demand generators in the literature are

considered to be the gross requirements generators for this research.

The literature related to the characterization of a requirements vector is found in a discussion of environmental factors in studies of the general discrete lot sizing problem and in the analysis of production inventory systems. These inventory systems have been categorized by: number of stages, number of products, continuity of demand and the certainty of demand [74]. In each of these categories, an initial demand or requirements vector is required to begin operation of the system. In the multiproduct model, each product has an initiating demand or gross requirements vector. In the multilevel model, the highest level (finished product or assembly) is initialized with a demand vector from which lower level gross and net requirements are computed. Because this research is concerned with the characterization of the initial vector, the distinction of number of products or number of stages in a system is not relevant. What is important are the characteristics of the vector. These characteristics, in turn, are derived from the method used to develop the vector.

The taxonomy used in this research, suggested by Wemmerlov and Whybark, is the dynamic or static nature of the requirements vector and the certain or uncertain nature

discrete	Certain	Dynamic	Prout [74]
			Biggs [12]
			Ludin and Morton [57]
			McLaren [61]
			Wemmerlov [93,94]
			Blackburn and Millen [15]
			Callarman and Whybark [22]
			Hemphill and Whybark [39]
		Static	Wagner and Whitin [89]
			Kaimann [46,47,48]
			Berry [10]
			Silver and Meal [81]
			Groff [36]
			Gaither [31]
			Callarman and Whybark [21]
			Wemmerlov [92]
	Uncertain	Dynamic	Prout [74]
			Whybark and Williams [97]
			Benton [7]
			Benton and Whybark [8,9]
			Wemmerlov and Whybark [95]
		Static	Kaimann [49,50]
			New [68]

Figure 3.1 --- Literature Classification

of the requirements [95]. A framework for this categorization of the literature is presented in Figure 3.1. In the following sections, each of these categories will be discussed.

Characterization of Requirements

Discrete, Certain, Dynamic Environment

A dynamic environment is one in which new periods and requirements are generated without end. The "observable" planning horizon, however, may be limited to some finite countable number of periods by either available data or system implementation. A manager may be able to see only the next (n) periods at any one time. At time (t) he has information concerning the requirements for period (t) to period (t+n). In period (t+1), his information is for period (t+1) through period (t+n+1). This continued revision of the observable planning horizon is termed a "rolling" schedule [95].

An early dynamic, multilevel, multiproduct study was performed by Prout [74] in 1972, to compare the relative economics of statistical and requirements planning techniques. His vehicle of analysis was a simulation model called "Production Control Project - DCIDE", which evaluated management techniques for deterministic and stochastic demand at the finished goods level. The demand pattern for

each of ten final products (SFG) used in the study was generated using the formula presented in Figure 3.2.

$$SFG(i) = [AS(i) + (t)BS(i) + CS(i) * (\sin \pi t/6)] * [1+E(i)]$$

where:

SFG(i) = Demand for product i
AS(i) = Basic value for product i
BS(i) = Linear Trend for product i
CS(i) = Seasonality factor for product i
E(i) = Normal random number with mean 0 and standard deviation specified for each product i
t = Current period of simulated operation

Figure 3.2 --- Production Control Project - DCIDE Demand Generator. [74]

The form of the demand vector was a sine wave imposed on a linear trend. The pattern was predictable and repetitive. A stochastic element could be added to demand through the multiplicative disturbance term [E(i)]. For deterministic demand the disturbance term was set to zero. In either the deterministic or stochastic form, a demand occurred each period. There were no intervals of zero demand for a product nor were any measures of the variability or lumpiness of the demand vector reported.

Another multistage, multiproduct simulation model was developed by Biggs [12] in 1975. His model, called Factory II, was designed to investigate the interaction of heuristic lot sizing techniques and lot sequencing rules given deterministic demand. The demand generation model he used was similar to that used by Prout in that it included a sinusoidal pattern and a trend factor. The disturbance term in Bigg's model was additive. The cyclical length of the sinusoidal pattern varied for each product and was from 3 to 12 periods. The demand generation model used in Factory II is shown in Figure 3.3. In this model, as in Prout's, demand occurred each period. No measure of the variability or lumpiness of the demand vector was reported.

A similar demand generator was reported in the same year by Lundin and Morton in their article on "Planning Horizons for the Dynamic Lot Size Model" [57]. The demand generator they used is presented in Figure 3.4. A geometric trend factor replaced the linear trend of Bigg's generator and a "phase shift", for position in a season, was added. This generator also resulted in a demand every period.

The Lundin and Morton research was directed to developing a procedure for finding a "near" planning horizon which could be used with forward algorithms such as the Wagner - Whitin algorithm. If an infinite planning horizon is not available, either because of restricted knowledge or computational capability, a finite horizon (T) must be

$$R(i) = Y(i)\,[\,1 + X(i)t + (\sin \pi\, t/Z(i))\,] + Eps(i)$$

where:
- R(i) = Demand for product i
- i = Product index number
- t = Current time of simulated operation
- Y(i) = Past demand (Y intercept of initialization)
- Z(i) = Demand coefficient for determining the length of sinusoidal pattern
- X(i) = Trend component of demand
- Eps(i) = Random variation in demand

Figure 3.3 --- Factory II Demand Generation Model

selected. The heuristic selection of "T" presumes some knowledge of the rate at which the infinite horizon solution and the "T" solution converge. A conclusion of their research was that "a 'near' horizon seems to be given empirically by $t = 5\sqrt{2K/hD}$ for the linear stationary case, where K is the setup cost, h the holding cost, and D the average demand rate" [57].

A more recent multilevel simulation study (1977) was performed by McLaren [61]. To provide values to a master schedule, McLaren developed a demand generator which, unlike the demand generators of Prout, Biggs, and Lundin and Morton, held average demand constant over all periods in the simulation. In addition, while seasonality and trend were

$$D = D(O)T^{t} \; [\, 1 + A \cos[(Bt + C)2\pi)] \; + SD(O)\xi$$

where:

D = Demand
t = Current time of simulated operation
D(O) = Base demand rate
T = Geometric trend factor
A = Seasonality factor
1/B = Length of the 'season'
C = Phase shift for position in season
SD(O) = Standard deviation of demand
ξ = Approximate normal deviate

Figure 3.4 --- Lundin and Morton Demand Generator

removed, specific recognition was taken of the lumpiness of demand. The lumpiness, measured by the coefficient of variation, was one of the factors in McLaren's experiments. Accordingly, his generator provided a vector of demands that had a predetermined coefficient of variation.

McLaren's method of generation is based on a uniform probability distribution. For low coefficients of variation a simple uniform distribution is used. The upper and lower limits of the distribution are established by a mean value and deviations from that mean. Variations in the coefficient of variation are obtained by changing the range

$$H = D\,(1 + Cv\sqrt{3})$$

$$L = D\,(1 - Cv\sqrt{3})$$

$$\bar{p} = 1$$

where:

H = Upper limit on uniform distribution
L = Lower limit on uniform distribution
D = Average period demand
$\bar{p}$ = Probability of demand in period
Cv = Coefficient of Variation

Figure 3.5 --- Formulas for Upper and Lower Limits of Uniform Distribution with Cv < 0.57735 [61].

of values included in the uniform distribution. The larger the range, the greater the value of the coefficient of variation. Because of the constraint that generated values be non-negative, the largest coefficient of variation that can be obtained using this form is 0.57735. The relationships used to generate the limits of the uniform distribution are shown in Figure 3.5.

Coefficients of variation larger than 0.57735 require the use of a compound probability distribution which is based on the combination of two distributions. Conceptually, the method samples from a uniform probability

distribution that specifies the conditional probability that a demand will occur in that period. If a demand is to occur, a uniform distribution is sampled to determine its magnitude. If a demand is not to occur, demand for that period is set to zero. To implement this demand generator, a special probability distribution is used with upper and lower limits determined by the formulas shown in Figure 3.6. Negative values sampled from the distribution are interpreted as periods of zero demand.

$$H = \frac{3\ D\ (Cv^2 + 1)}{2}$$

$$L = H[\ 1 - 3/4\ (\ Cv^2 + 1\ )\ ]$$

$$\bar{p} = \frac{4}{3(\ Cv + 1)}$$

Figure 3.6 --- Formulas for Upper and Lower Limits of "Special" Distribution used in McLaren's Demand Generator [61].

To summarize McLaren's method, a demand vector can be generated with a specified overall average period value and coefficient of variation. The coefficient of variation is

over all periods and includes periods of no demand as well as periods of positive demand. Because of the method of generation, a coefficient of variation less than 0.57735, produces a positive demand in every period. For larger coefficients of variation, the frequency of occurrence of demand is a function of the coefficient of variation. The higher the coefficient of variation, the higher the proportion of periods with no demand. The McLaren demand generator has received wide general acceptance and appears in numerous articles [7,8,9,22,39,61,93,95,97].

In a two-part report, Blackburn and Millen [15] provided analytical and simulated analysis of the procedures "Part - Period - Cost Balancing" (PPB) and "Minimum - Cost - Per - Period" (SM). The analytical portion of the report assumed an infinite planning horizon and constant demand. To perform the empirical portion of the study with a certain, non- zero variance demand vector, Blackburn and Millen used three different types of distributions. The first was a uniform distribution with lower limit of 100 and upper limit of 300 [U(100,300)], the second a normal distribution with mean of 200 and standard deviation of 20 [N(200,20)] and the last a compound distribution with demand in any period equal to zero with probability of .2; otherwise demand was normally distributed with mean of 250, and standard deviation of 20 [N(250,20) 20%]. The latter was chosen "... to represent 'lumpy demand' which frequently

occurs in requirements planning" [15]. To investigate the effect of increased lumpiness, the standard deviation of the normal distribution was doubled as was the range of the uniform distribution. In each case, increased lumpiness was defined by an increase in standard deviation or range of values for similar distributions. Unlike the McLaren procedure, the frequency of occurence of demand did not change with increased lumpiness. A normal distribution with a given standard deviation was only compared to another normal curve with a larger standard deviation. No general measure, such as the coefficient of variation, was given.

To provide a point of reference, 5000 samples were drawn, from the compound normal and uniform distributions used by Blackburn and Millen. Graphs of the frequency distributions of the generated demand vectors are depicted in figures 3.7 through 3.10. In each of the graphs, the actual generated demand values are grouped in 10 unit intervals. It is noted that the coefficient of variations for graph 3.7 [N(250, 20) 20%], graph 3.9 [N(250,40) 20%], and graph 3.10 [U(100,400)] differ by less then .07. For comparison, a graph showing the frequency distribution of demands using McLaren's generator with mean and coefficient of variation the same as for the Blackburn and Millen model shown in Figure 3.7, is presented in Figure 3.11. A comparison of the two models indicates that McLaren's model has a requirement every period while the Blackburn and

Millen model has a demand in 80% of the periods. In addition, while there is very small probability that demand in the Blackburn and Millen model will fall outside the two standard deviation range of 210 to 290, in the McLaren model values from 23.3 to 376.7 are equally likely.

In a comparison of discrete, single stage lot sizing procedures, Wemmerlov [94] performed a simulation experiment and also used demands generated from three different types of distributions. The first type was a normal distribution, the second a uniform distribution and the third a normal distribution with mean of 32.7, with standard deviation of 81.8, and with values less than zero censored at zero [CN(32.7,81.8)]. While Wemmerlov does not specify why the particular distributions were selected, he accepts the coefficient of variation as a measure of 'lumpiness' and does not distinguish between demand vectors with the same coefficient of variation developed from different distributions. In a manner similiar to McLaren, Wemmerlov includes all periods in his computation of the coefficient of variation. He notes that while the coefficient of variation does not uniquely describe a certain demand pattern, "a specific environment can ... be described by {Cv, D, S/IC} or {Cv, TBO}" [94].

FREQUENCY DISTRIBUTION OF GENERATED DEMANDS

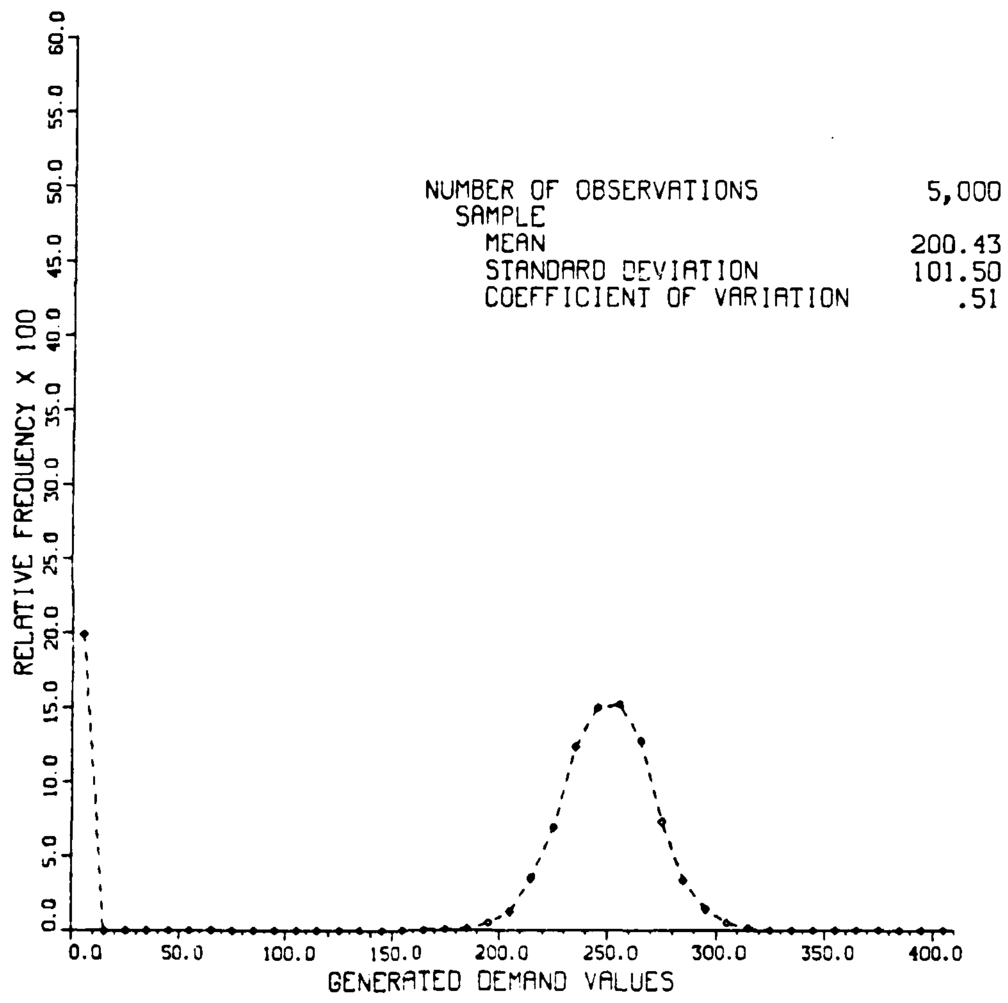


FIGURE 3.7 - BLACKBURN AND MILLEN DEMAND GENERATOR
WITH 80 PERCENT PROBABILITY OF DEMAND
[N(250,20) 20]

FREQUENCY DISTRIBUTION OF GENERATED DEMANDS

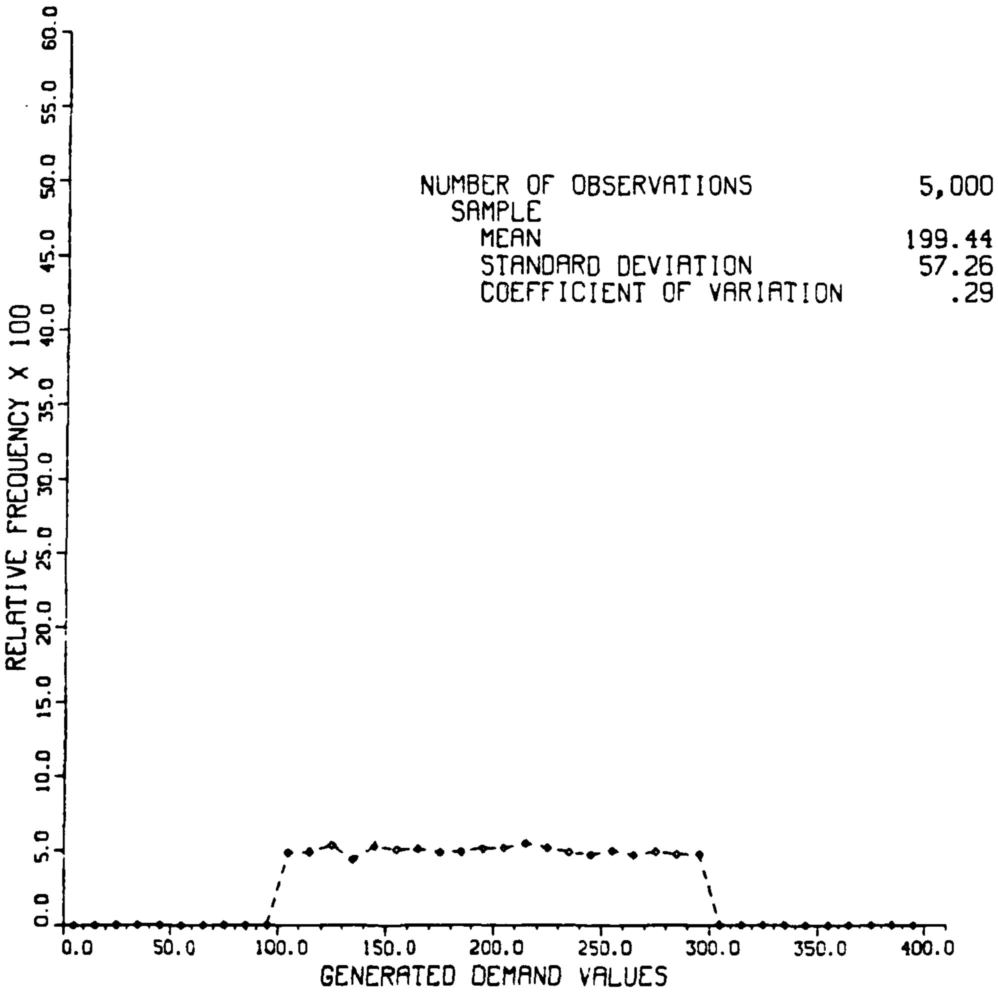


FIGURE 3.8 - BLACKBURN AND MILLEN DEMAND GENERATOR
WITH UNIFORM DISTRIBUTION
(LIMITS LOW-100, HIGH-300)

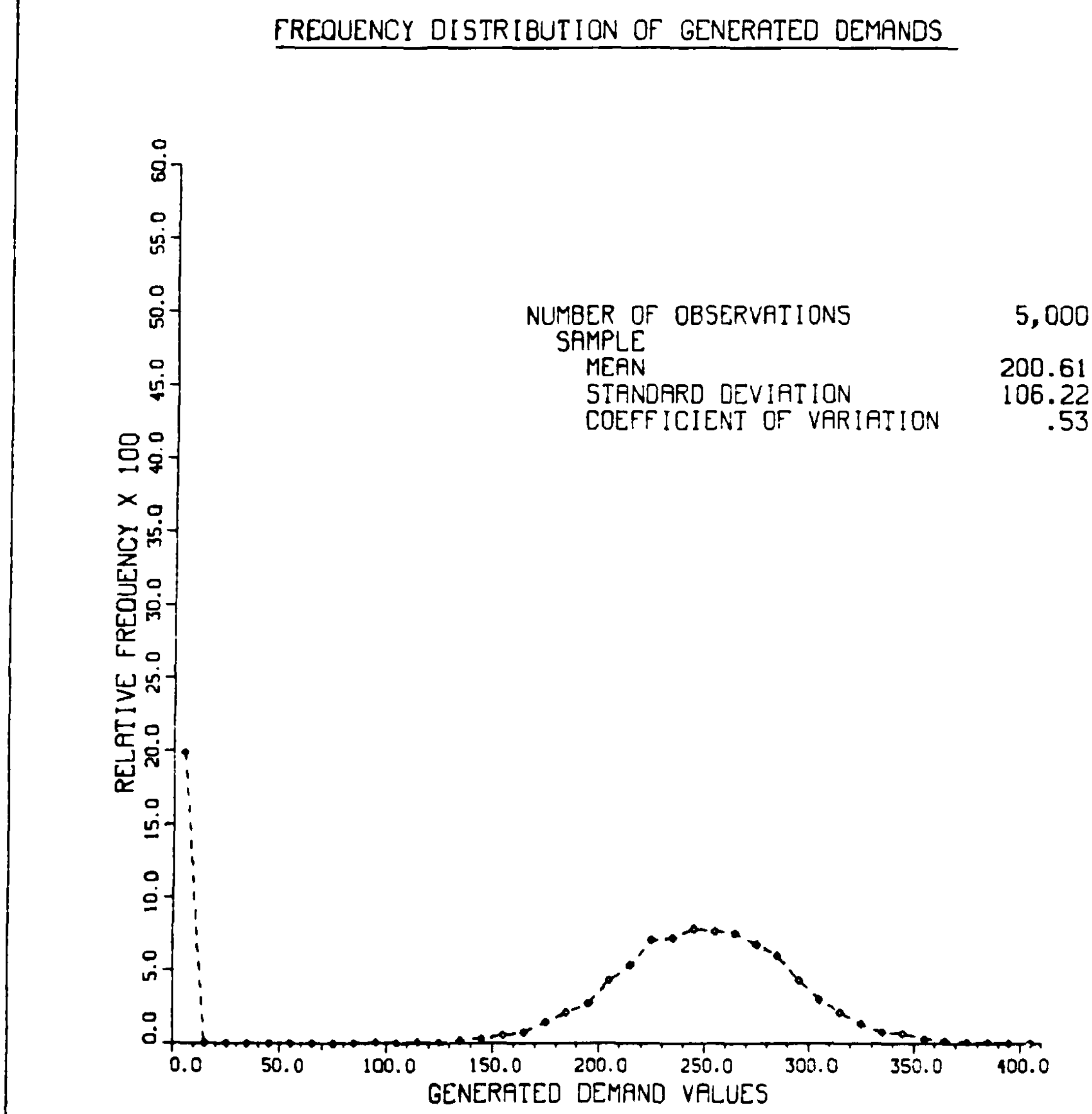


FIGURE 3.9 - BLACKBURN AND MILLEN DEMAND GENERATOR WITH 80 PERCENT PROBABILITY OF DEMAND [N(250,20) 40]

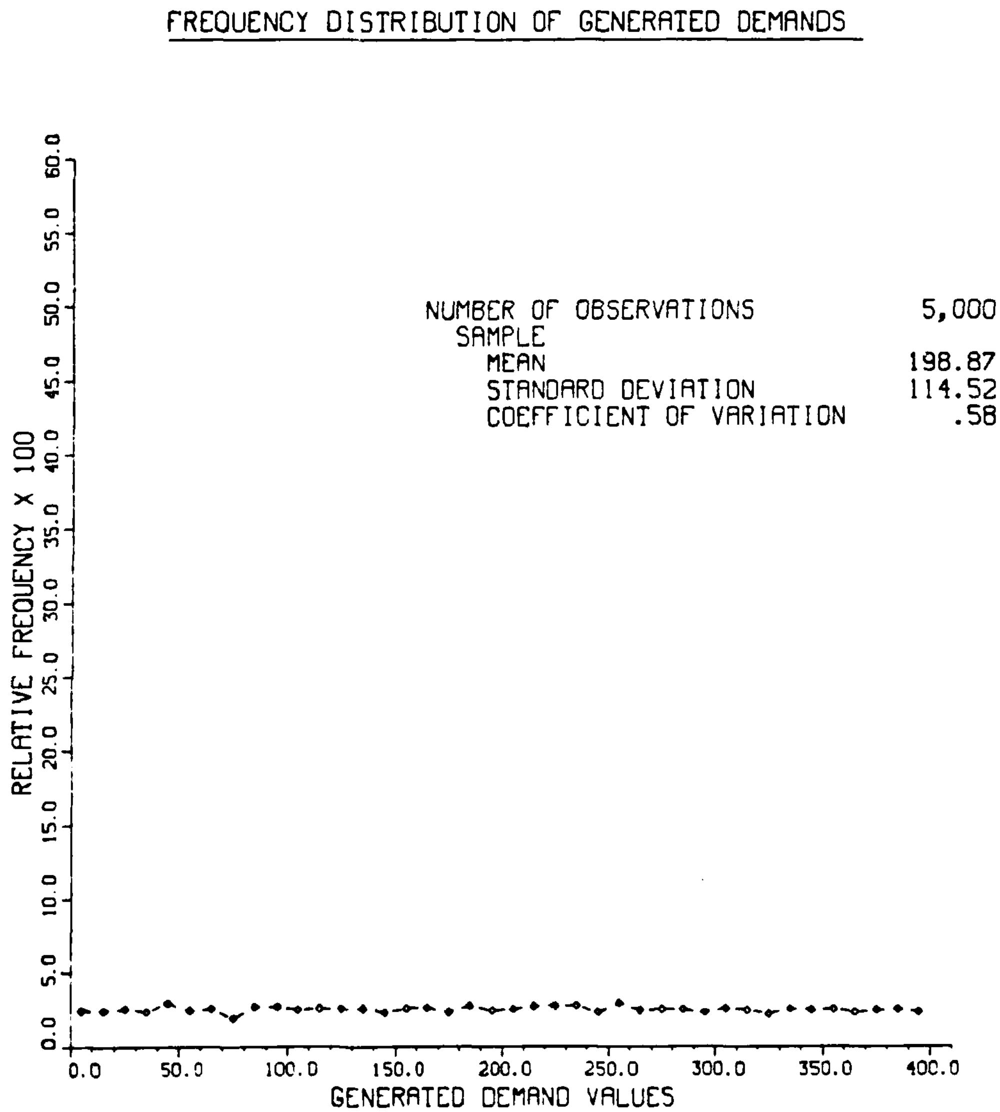


FIGURE 3.10 BLACKBURN AND MILLEN DEMAND GENERATOR
WITH UNIFORM DISTRIBUTION
(LIMITS LOW-0, HIGH-400)

FREQUENCY DISTRIBUTION OF GENERATED DEMANDS

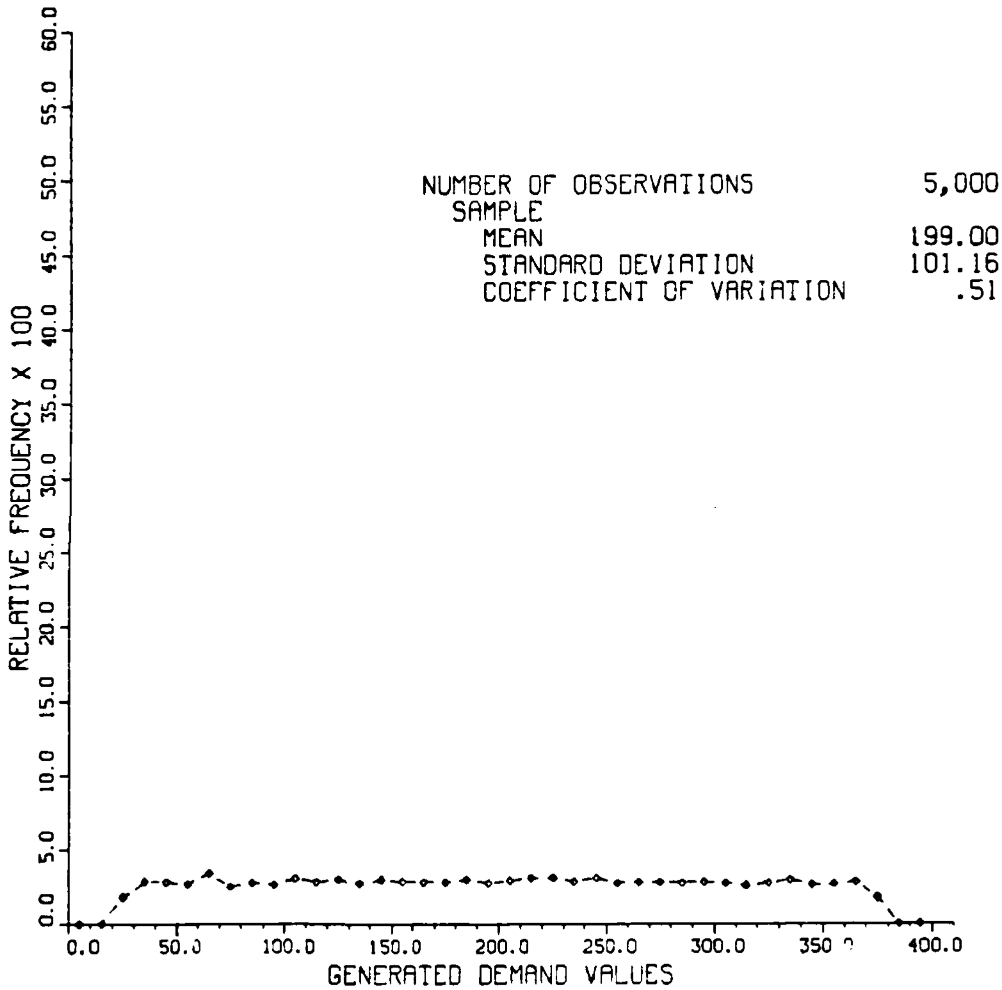


FIGURE 3.11 MCLAREN DISTRIBUTION WITH SAME COEFFICIENT OF VARIATION AS BLACKBURN AND MILLEN DISTRIBUTION SHOWN IN FIGURE 3.7

Three distributions used by Wemmerlov were: N(50,7.5); U(0,100); and CN(32.7,81.8). The normal and censored normal distributions were sampled 5000 times, and the frequency distributions of those samples are shown in Figures 3.12 and 3.13. As a point of reference, the frequency distribution shown in Figure 3.14, was generated using McLaren's method and has the same coefficient of variation and approximately the same mean as Wemmerlov's censored normal distribution. While McLaren's demand generator does result in a slightly higher probability of very small demand (44% vs 38%), the frequency distributions are similar.

Discrete, Certain, Static Environment

A discrete, certain, static environment is one in which there are a fixed, known number of periods in which a requirement may exist. Demand vectors in this environment are frequently drawn by a researcher from an unknown distribution. The application is normally to introduce a new concept or provide an intuitive understanding of an existing relationship. One of the earliest such demand vectors was used by Wagner and Whitin [89] in 1958 to introduce the dynamic version of an economic lot size model.

FREQUENCY DISTRIBUTION OF GENERATED DEMANDS

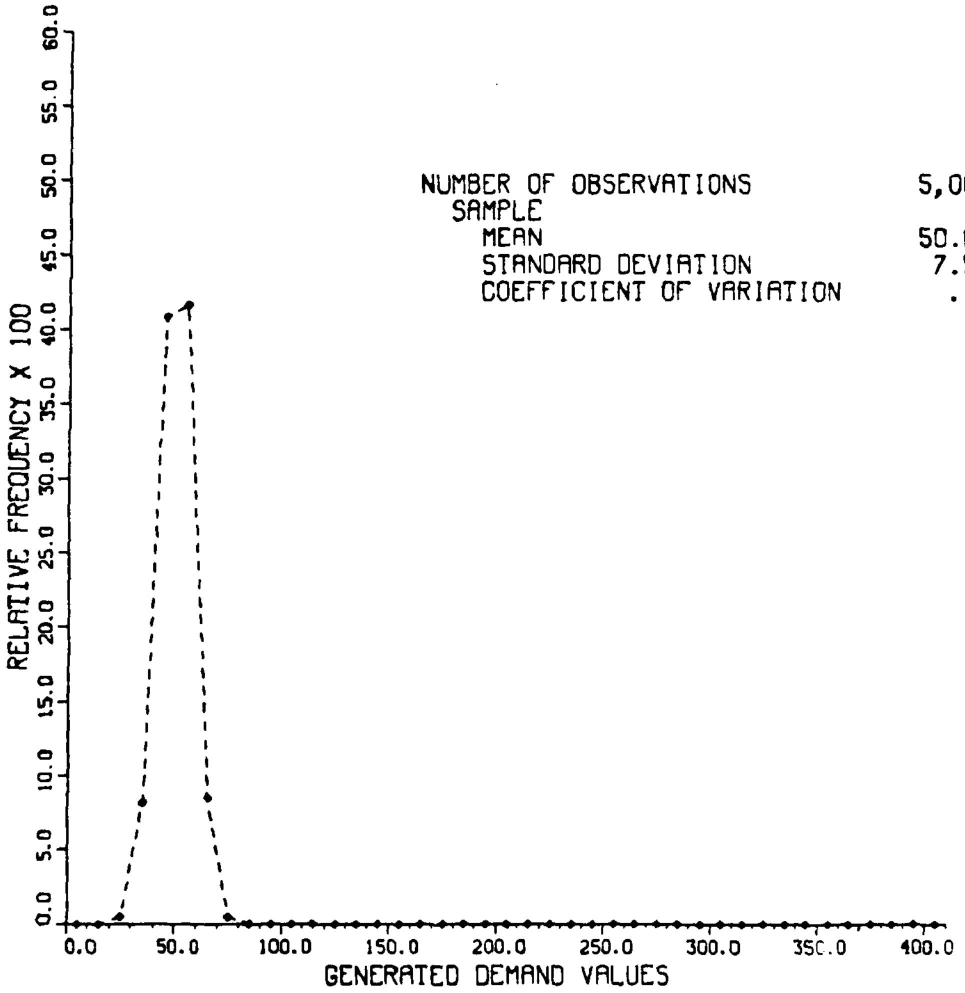


FIGURE 3.12 WEMMERLOV NORMAL
DEMAND GENERATOR

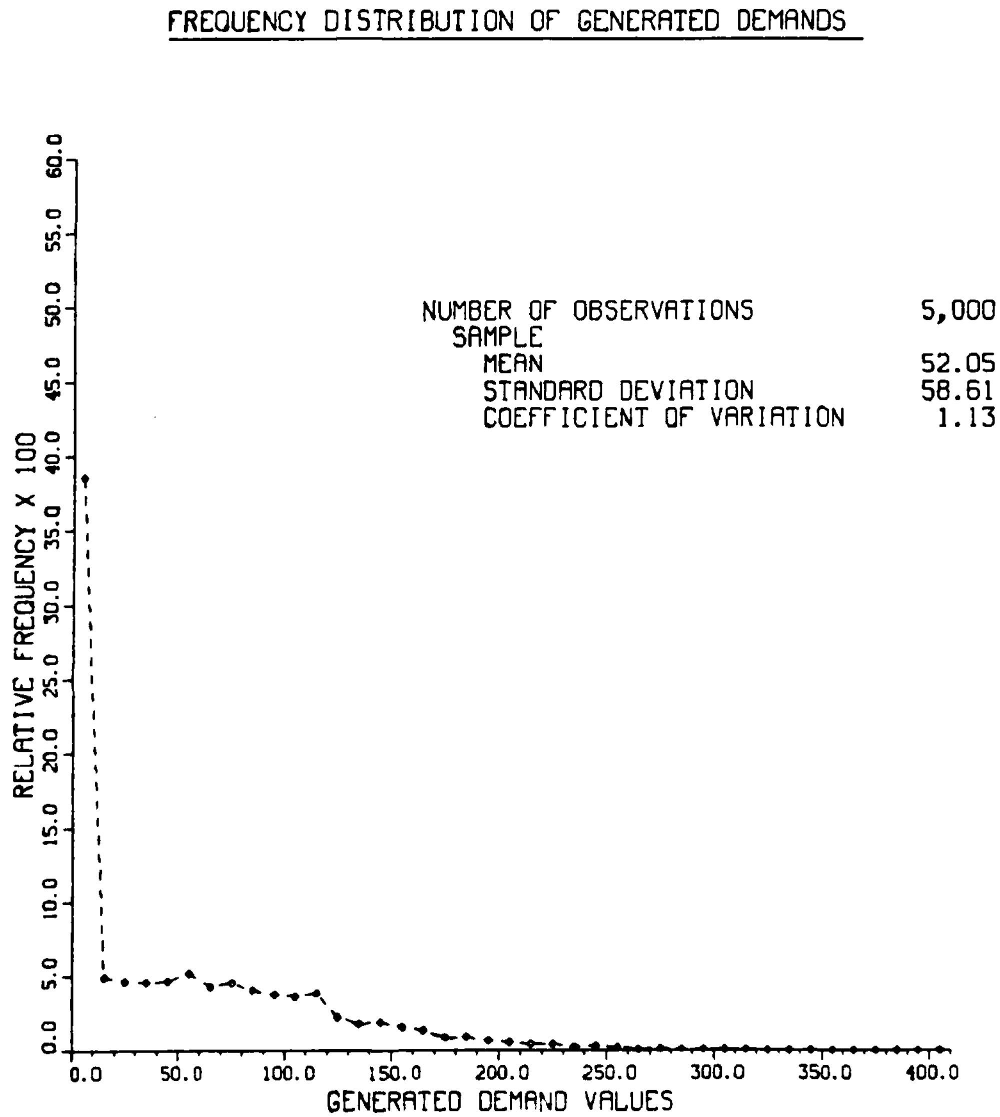


FIGURE 3.13 WEMMERLOV CENSORED NORMAL DEMAND GENERATOR [CN(32.7, 81.81)]

FREQUENCY DISTRIBUTION OF GENERATED DEMANDS

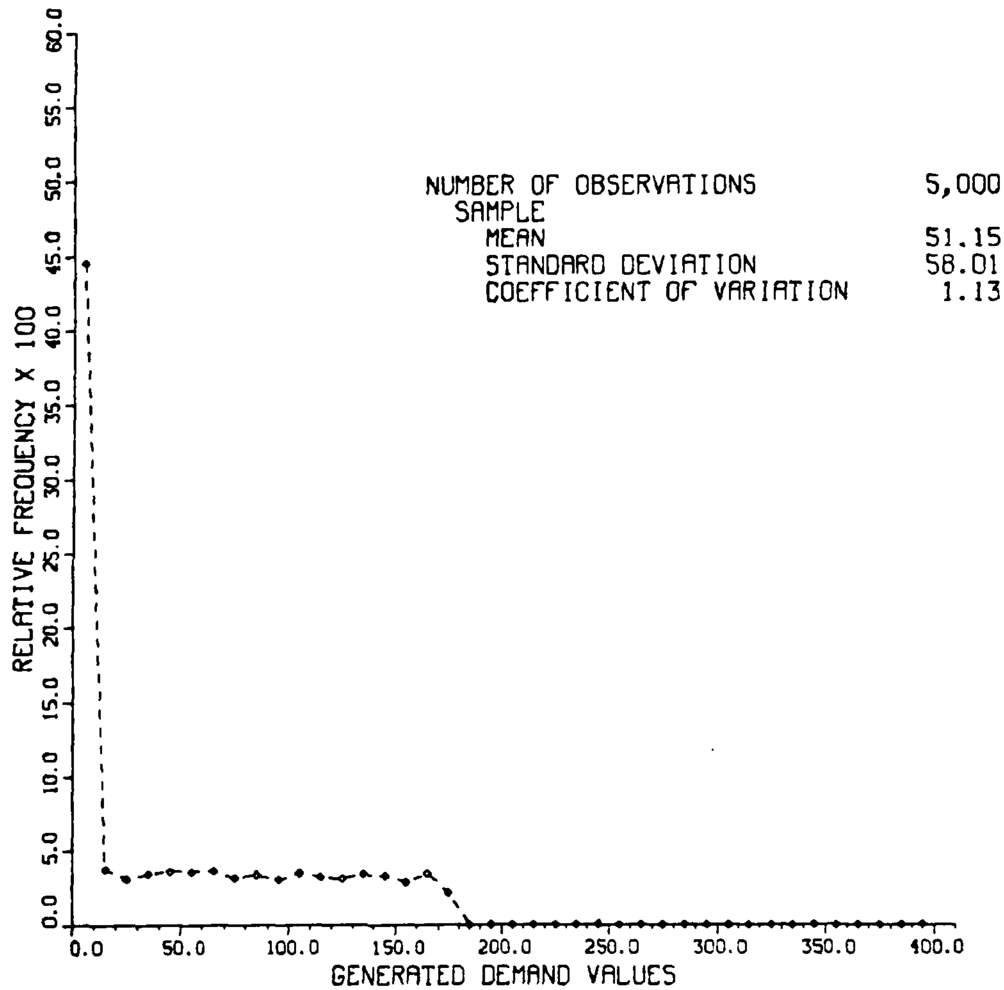


FIGURE 3.14 MCLAREN DISTRIBUTION WITH SAME COEFFICIENT OF VARIATION AS WEMMERLOV DISTRIBUTION OF FIGURE 3.13

	Data Sets						
period	-a-	-b-	-c-	-d-	-e-	-f-	-g-
1	80	80	50	10	0	92	0
2	100	100	80	10	0	92	0
3	125	125	180	15	0	92	0
4	100	100	80	20	25	92	0
5	50	270	0	70	100	92	0
6	50	50	0	180	300	92	1105
7	100	230	180	250	400	92	0
8	125	0	150	270	250	92	0
9	125	50	10	230	30	92	0
10	100	0	100	40	0	92	0
11	50	40	180	0	0	92	0
12	100	60	95	10	0	92	0

Figure 3.15 -- Static Data Sets Common to the Literature.

A set of demand vectors which occurs frequently in the literature was introduced by Kaimann [46] in 1968. That data set is presented in figure 3.15 as data set "a". Later, in the same year data set "b" was added [47]. Finally in 1969, Kaimann [49] introduced an expanded data which included the previous two vectors. The subset {b,c,e,f,g}, of this group appears to have become the standard static data set for testing lot sizing procedures and has been used by Kaimann [46,47,48,49,50], Berry [10], Silver and Meal [81], Groff [36], Gaither [31] and Wemmerlov [92].

Discrete, Uncertain, Dynamic Environment

The characterization of a requirements vector may include the element of uncertainty. The usual method of developing an uncertain requirements vector is to initially generate a certain requirements vector which is modified, using one of the methods described below, to incorporate uncertainty. In at least one technique, the coefficient of variation is used as the measure of uncertainty [49].

Uncertainty in an MRP environment has been characterized by Whybark and Williams as consisting of timing or quantity deviations for either demand or supply [97]. "The level of uncertainty is measured by the standard deviation of the difference between projected inventory balance and actual inventory balance" [97].

Uncertainty is considered a factor, in a rolling schedule environment, only within the planning horizon. At period (t), with a planning horizon of (n) periods, information concerning the requirement for period (t+n+1) is not available. The absence of that information is not considered uncertainty. Within the planning horizon, certainty and uncertainty are distinguished in the conventional manner. In the uncertain case, the planning horizon remains (n) periods but only the current and prior

period requirements are known. Requirements for period (t+1) to the planning horizon (t+n) are subject to error. In the certain case, the requirements for each of the (n) periods in the horizon are known.

Uncertainty in a demand or requirements vector is usually interpreted as quantity uncertainty. Benton refers to requirements uncertainity as the "difference between planned requirements and actual requirements for a period" [7]. This type of uncertainty may be introduced into a previously generated requirements vector through either a multiplicative or additive uncertainty factor. The method selected will influence the coefficient of variation of the requirements vector.

The Prout demand generator, previously described and shown in Figure 3.2, incorporated a multiplicative uncertainty factor. A random deviate, E(i), was drawn from a normal distribution with mean 0.0 and standard deviation specified for each individual item. The standard deviation for every item was less than .25. The certain requirements vector was multiplied by [1+E(i)] to determine the corresponding uncertain requirements vector. Since the deviates were drawn from a symmetric distribution with a relatively small standard deviation, the mean of the uncertain vector closely approximated the mean of the certain vector. In addition, since the deviation of demand was a constant proportion of the mean demand over time, the

number of standard deviations of deviate from mean	[1+E(i)]	certain value 10	100	400
		uncertain value		
2	1.50	15	150	600
1	1.25	13	125	500
-1	.75	8	75	300
-2	.50	5	50	200

Deviation Distribution: normal
mean 0.00
standard deviation .25

Figure 3.16 -- Multiplicative Method of Generating Uncertain Requirements.

coefficient of variation was constant [74]. An illustration of this procedure is given in Figure 3.16.

The demand generators used by Benton, Wemmerlov and Whybark incorporated an additive uncertainty factor [7,95]. In their generators, a forecast (certain) requirements vector with a given coefficient of variation was determined using McLaren's procedure. Next, a deviation vector was developed by drawing deviates from a normal N(0,1) distribution and multiplying the deviates by a scaling factor. The sum of the forecast and deviation vectors

number of standard deviations of deviate from mean	deviate times scaling factor	certain value 10	100	400
		uncertain value		
2	160	170	260	560
1	80	90	180	480
-1	-80	-70	20	320
-2	-160	-150	-60	240

Deviation Distribution: normal   Scaling Factor 80
mean 0.0
standard deviation 1.0

Figure 3.17 -- Additive Method of Generating Uncertain Requirements.

represented unadjusted uncertain requirements. If a scaled deviate for a particular element was negative and its absolute value exceeded the certain requirement, the sum would be negative. The vector was therefore adjusted in two ways. First, negative requirements were considered periods of no requirements and set to zero. Second, because of the increased number of periods with zero demand, the vector was normalized to the same mean as the unadjusted vector.

period	1	2	3	4	5	6	7	8
	55	0	215	0	200	75	60	195

3.18 a --- Certain vector
Coefficient of Variation 0.98
Mean requirement 100.00

period	1	2	3	4	5	6	7	8
	-60	0	50	0	20	-85	70	5

3.18 b --- Deviation vector

period	1	2	3	4	5	6	7	8
	-5	0	265	0	220	-10	130	200

3.18 c --- Unadjusted summation vector
Coefficient of Variation 1.17
Mean requirement 100.00

period	1	2	3	4	5	6	7	8
	0	0	260	0	216	0	128	196

3.18 d ---Adjusted summation vector
Coefficient of Variation 1.13
Mean requirement 100.00

Figure 3.18 -- Unadjusted and Adjusted Requirements Vectors for Additive Uncertainty.

As the scaling factor increased relative to the mean, however, the difference in the coefficient of variation between the uncertain vector and the forecast vector also increased. The additive method of generating an uncertain requirements vector is illustrated in Figure 3.17. Certain, deviation, Unadjusted and adjusted requirements vectors are shown in Figure 3.18.

The additive method for introducing uncertainty was also used by Whybark and Williams [97]. Their procedure paralleled that of Benton except in their method of finding the quantity deviation vector. Rather than use a normal deviate and scaling factor, Whybark and Williams sampled directly from a uniform distribution.

Discrete, Uncertain, Static Environment

Kaimann [49] introduced a procedure for incorporating safety stock for the dynamic programming model in a discrete, uncertain static environment. The key to his procedure was the "upward adjustment of demand for each period to allow a 95% service level. The adjustment he proposed was based on increasing a period's forecast demand by a multiple of the standard deviation of that period's demand. The area of interest to this research is the method he suggested for finding the standard deviation. He proposed:

> "The coefficient of variation provides a relative measure of the dispersion for the time series. As the series becomes more erratic, the coefficient grows. Since each period contributes to the dispersion, one assumption would be to calculate a period standard deviation based on 1/12 of the coefficient of variation" [49].

For a 12 period planning horizon, he computed the standard deviation for each period as:

$$s(i) = Cv \quad x(i) \cdot 1/12$$

where

$s(i)$ = standard deviation for period i
Cv = Coefficient of variation
$x(i)$ = Average demand in period i [49]

In this application, the coefficient of variation is used as a measure of uncertainty. Kaimann did not indicate how to distinguish that portion of the coefficient of variation which was caused by the lumpiness of demand from that portion caused by uncertainty.

Lot Sizing Algorithms

This research is concerned with the adequacy of the coefficient of variation as a solitary measure of lumpiness. The environment in which this question becomes important is in the selection of a lot sizing procedure. In view of this, a selected subset of the available lot sizing procedures which have particular relevance to our purpose will be reviewed here . The interested reader will find a

broader treatment of lot sizing algorithms available in numerous excellent comparative studies [10,15,48,70,86,92]. For each of the algorithms described in the following sections, demonstration calculations will be performed on a sample problem taken from Orlicky [70].

Periodic Order Quantity (POQ)

The POQ has been identified by Wemmerlov, in a limited survey of MRP users, as the procedure used most frequently in industry [91]. It is an adaptation of the traditional Economic Order Quantity (EOQ) modified to conform to fixed time interval ordering. In the EOQ procedure, a mismatch may occur between the quantity ordered and discrete period requirements causing "remnants" to be carried into a peric in which a new replenishment order is scheduled to arrive. The POQ converts the EOQ into a time interval between replenishment orders (TBO) which, rounded to the nearest integer, defines the number of periods demands to be included in each lot ordered. The calculation of the POQ for the sample problem is shown in Figure 3.19.

Groff

The Groff lot sizing procedure has been recommended by Wemmerlov in a comparative analysis of lot sizing heuristics as the "best discrete, single stage heuristic available for

Order Cost	(S)	= $100
Unit cost	(C)	= 50
Holding cost	(I)	= .24% per annum
	(Ip)	= .02% per period
Annual demand		= 200 units
Number of periods per annum		= 12
Average period demand (d)		= 16.67

step 1: Compute EOQ.

$$EOQ = \sqrt{\frac{(2)(d)(S)}{Ip}}$$
$$= 57.73$$

step 2: Convert EOQ to time interval between orders

TBO = EOQ/d
= 3.46

step 3: Round TBO to integer number of periods > 1

N* = 3

step 4: Order N* periods demand.

period	1	2	3	4	5	6	7	8	9
d(i)	35	10	0	40	0	20	5	10	30
Lot size	45			60			45		
Inventory									
beginning	45	10	0	60	20	20	45	40	30
ending	10	0	0	20	20	0	40	30	0

Holding cost	195
Order cost	300
Total cost	495

Figure 3.19 -- Example of Periodic Order Quantity Lot Sizing Procedure

```
      n = Number of periods in advance of the current
          period
      R = Cumulative order size
    EPP = Economic Part Periods

step 1: Compute:
           EPP = Setup cost / per period holding cost;
               = 100/1
               = 100
        Let n = 1;
        Let R = 0;
        Go to step 2.

step 2: Let n* = (n)(n-1);
        (n*)(d(i)) < (2)(EPP) ?
           Yes - go to step 3.
           No -- go to step 4.

step 3: Let R = R + d(n);
        Let n = n + 1;
        Go to step 2.

step 4: Order R.
```

Figure 3.20 -- Example of Groff Lot Sizing Procedure (continued)

		period	1	2	3	4	5	6	7	8	9
		d(i)	35	10	0	40	0	20	5	10	30
		R	35	45	45						
(a)		(n*)(d(i))	0	20	0	480					
		(2)(EPP)	200	200	200	200					
		(a) < (2)(EPP)	yes	yes	yes	no					
		n				1	2	3	4	5	
		R				40	40	60	65		
(a)		(n*)(d(i))				0	0	120	60	200	
		(2)(EPP)				200	200	200	200	200	
		(a) < (2)(EPP)				yes	yes	yes	yes	no	
		n								1	2
		R								10	40
(a)		(n*)(d(i))								0	60
		(2)(EPP)								200	200
		(a) < (2)(EPP)								yes	yes
		Lot size	45			65				40	
Inventory											
		beginning	45	10	0	65	25	25	5	40	30
		ending	10	0	0	25	25	5	0	30	0

Holding cost	170
Order cost	300

Total cost	470

Figure 3.20 -- Example of Groff Lot Sizing Procedure (continued)

use in an uncapacitated environment" [94]. This procedure is based on equating the marginal inventory ordering costs and the marginal inventory holding costs. The rule is to accumulate additional periods demands in a lot as long as the marginal increase in holding costs is less than the marginal increase in ordering costs. An example calculation of this procedure is given in Figure 3.20.

McLaren's Order Moment (MOM)

The McLaren order moment lot sizing algorithm is a target based rule [94]. The objective of MOM is to match the number of accumulated part periods with the number that would be incurred if an order for the EOQ was placed under conditions of constant demand. The target is found by multiplying the demand (the "force") by the number of periods it is carried in inventory (the "moment arm") [61].

The order moment heuristic is implemented by consecutively considering each demand. Each demand is added to a tentative amount to order until the accumulated part periods equal or exceed the target. The order moment, for the last demand considered, is compared to the ratio of setup to holding cost. If the order moment is less than the

n = Number of periods in advance of the current period.
CPP = Cumulative part periods
R = Cumulative order size
TBO = Time Between Orders
T* = Largest integer less than or equal to TBO
PPT = Part Period Target

step 1: Compute:

$$PPT = d\{ \sum_{t=1}^{T^*-1} t + [TBO - T^*]\, T^* \}$$

$$= 73$$

where: [ ] designates integer part
TBO = 3.46 from figure 3.19

step 2: Let n = 1;
Let CPP = 0;
Let R(n) = d(n).

step 3: CPP > PPT ?
No -- go to step 4.
Yes - go to step 5.

step 4: Let n = n + 1;
Let R(n) = R(n-1) + d(n);
Let CPP(n) = CPP(n-1) + (n-1)(d(n))
Go to step 3.

step 5: (n-1)(d(n)) < EPP ?
Yes -- order R(n).
No -- order R(n-1).

Figure 3.21 -- Example of McLaren Order Moment Lot Sizing Procedure (continued)

period	1	2	3	4	5	6	7	8	9
d(i)	35	10	0	40	0	20	5	10	30
R	35	45	45	85					
CPP	0	10	10	130					
PPT	73	73	73	73					
CPP > PPT	no	no	no	yes					
n				1	2	3	4	5	
R				40	40	60	65	75	
CPP				0	0	40	55	95	
PPT				73	73	73	73	73	
CPP > PPT				no	no	no	no	yes	
n									1
R									30
CPP									0
PPT									73
CPP > PPT									no
Lot size	45			75					30
Inventory									
beginning	45	10	0	75	35	35	15	10	30
ending	10	0	0	35	35	15	10	0	0

Holding cost	180
Order cost	300

Total cost	480

Figure 3.21 -- Example of McLaren Order Moment Lot Sizing Procedure (continued)

```
      n = Number of periods the current replenishment quantity
          is to last.
    CPP = Cumulative part periods
      R = Cumulative order size
    EPP = Economic Part Periods
        = Setup Cost/ Per Period Holding Cost

step 1: Let n = 1;
        Let CPP(1) = EPP;
        Let R = d(n)
        Go to step 2.

step 2: n²(d(i+1)) > CPP(n) ?
           No -- go to step 3.
           Yes - go to step 4.

step 3: Let n = n + 1;
        Let R = R + d(n);
        Let CPP(n) = CPP(n-1) +(n-1)(d(n))
        Go to step 2.

step 4: Order R.
```

Figure 3.22 -- Example of Silver Meal Lot Sizing Procedure (continued)

	period	1	2	3	4	5	6	7	8	9
	d(i)	35	10	0	40	0	20	5	10	30
	R	35	45	45						
(a)	CPP	100	110	110						
(b)	n^2(d(i+1))	10	0	360						
	(b) > (a)	no	no	yes						
	n				1	2	3	4		
	R				40	40	60	65		
(a)	CPP				100	100	140	155		
(b)	n^2(d(i+1))				10	80	45	160		
	(b) > (a)				no	no	no	yes		
	n								1	2
	R								10	40
(a)	CPP								100	130
(b)	n^2(d(i+1))								30	–
	(b) > (a)								no	–
	Lot size	45			65				40	
Inventory										
	beginning	45	10	0	65	25	25	5	40	30
	ending	10	0	0	25	25	5	0	30	0

Holding cost	170
Order cost	300

Total cost	470

Figure 3.22 -- Example of Silver Meal Lot Sizing Procedure (continued)

ratio, that demand is included in the amount to order. If not, it becomes the first demand of the next cycle. An example of this procedure is given in Figure 3.21.

Silver-Meal (SM)

The Silver-Meal lot sizing procedure finds the minimum total cost per unit time over the time period that the order quantity lasts [81]. The order quantity is determined by accumulating successive period demands until the ratio of cost per unit time would increase with the addition of the next demand. The horizon considered extends only to the next period of demand; therefore, the procedure only guarantees a local minimum in the cost per unit time [81]. This procedure has been shown to be superior to other rules in several comparative studies [15,71,81,94,95]. An example of this procedure is shown in Figure 3.22.

Summary

In an MRP environment, discrete requirements occur at fixed intervals of time. These requirements may be the same magnitude each period or they may vary from period to period. This difference of requirement magnitude has been termed variability or lumpiness. The generally accepted measure of this lumpiness is the coefficient of variation. [7,10,15,21,39,46,61,91]. To represent this lumpy demand in

dynamic simulation experiments, several demand generators have been developed which exibit different characteristics. In this chapter we have described these generators and presented frequency distributions of samples taken from three of them.

The environment in which the characterization of a requirements vector is frequently considered, is in the selection of a lot sizing procedure. In this chapter we have described and demonstrated selected lot sizing procedures which are either commonly used or which have been identified in comparative analysis as worthy of further consideration.

In chapter II we provided a tenative definition of lumpiness. In this chapter we have reviewed lumpy demand vectors currently used in the literature. In chapter IV we will develop our model for evaluating the adequacy of the coefficient of variation as a descriptor of those demand vectors.

CHAPTER IV

Methodology for Evaluating the Coefficient of Variation

This research is concerned with the adequacy of the coefficient of variation as a descriptor of a requirements vector. The environment in which this question becomes important is in the selection of a lot sizing procedure. Chapter II introduced the problem of capturing the essential characteristics of a requirements vector, which influence the total cost performance of lot sizing techniques used in an MRP environment. A perspective for this research was provided in Chapter III by reviewing the literature related to the characterization of requirements vectors and the procedures currently used for generating requirements vectors for experimentation. In addition, selected lot-sizing procedures for discrete, single level, single item, requirements vectors were illustrated.

This chapter will present the methodology for evaluating the coefficient of variation as a descriptor of a requirements vector. The criterion used in the evaluation is the percentage total cost deviation of a selected lot-sizing algorithm from a selected base lot- sizing algorithm.

To study the coefficient of variation we will use a model characterized by the procedure used to generate the requirements vector (GEN), the grouping of the requirements vector (GP), the time between orders (TBO), a selected group of lot-sizing algorithms (LS), and the coefficient of variation (Cv). Each of these factors is described in the following paragraphs of this chapter. In addition, an explanation of the method used to develop the generation and periodicity factors and the specific levels of all factors is presented.

The vehicle for experimentation in this study is a computerized MRP model written in Simscript II.5. The salient features of the computer model will be described. The final section of this chapter deals with the experimental design. In that section, we will present the formal research hypotheses. Chapter V will present the results of the experiments.

Coefficient of Variation

The Coefficient of Variation is defined as the ratio of the standard deviation of demand per period to the average demand per period. By convention, all periods in a requirements vector are included in the computation of the coefficient of variation [7,10,36,48,61,94,97].

While the coefficient of variation does provide a general measure of "lumpiness", it may not be a sufficient characterization of the demand vector if the pattern of requirement occurrences influences the total cost performance of lot-sizing algorithms. A particular requirements vector will map into a single coefficient of variation. A single coefficient of variation, however, may map into more than one requirements vector as shown in Figure 4.1. That figure presents several vectors which have a common coefficient of variation of 1.82 and positive requirements in 3,4,5,6,7 and 8 periods, respectively, of a ten-period horizon.

124	438	438	0	0	0	0	0	0	0
57	57	443	443	0	0	0	0	0	0
100	100	100	101	599	0	0	0	0	0
76	79	79	79	79	607	0	0	0	0
63	65	65	65	65	65	612	0	0	0
55	55	55	55	55	55	55	615	0	0

Average period requirement = 100
Coefficient of variation = 1.82

Figure 4.1 --- Requirements Vectors with a Coefficient of Variation of 1.82

Three levels of the coefficient of variation (Cv = .29, .72 and 1.14) were chosen in this research for consistency with prior studies [7,10,22,39,48,94] and to provide requirements vectors which, under the methods of generation to be explained in following sections, would exhibit a distribution of frequencies of null requirements that did not exceed fifty percent of the total number of periods. Very high coefficients of variation were excluded to preclude the occurrence of very sparse requirements vectors. The probability of a requirement occurring in each period is indicated for the McLaren, Wemmerlov and Blackburn and Millen procedures in Figures 4.2, 4.7 and 4.11 respectively.

Generation of Requirements Vectors

Dynamic procedures for generating requirements vectors were developed by McLaren [61], Wemmerlov [94], and Blackburn and Millen [16]. Each of these methods characterizes the requirements vector through samples drawn from different populations. Wemmerlov states that "... a specific environment can, thus, be described by either {Cv, D, S/IC } or {Cv, TBO }" [94]. In this study the coefficient of variation (Cv) is set at the previously specified levels and average period demand (D) is held constant at 100 units per period for all experiments. The procedures described by McLaren, Wemmerlov and Blackburn and Millen are used to generate requirements vectors which have

the same average period demand and coefficient of variation.

McLaren

McLaren's procedure for generating a requirements vector is based on sampling from a uniform distribution that has upper and lower limits prescribed by the formula given in Figure 3.5, for coefficients of variation less than or equal to 0.57735, and by Figure 3.6 for coefficients of variation greater than 0.57735. The distribution parameters computed using these formulas are presented in Figure 4.2. Samples drawn from the uniform distribution that have a value less than zero are assigned a value of zero. That is, negative values are interpreted as periods of null requirements.

Coefficient of Variation	Limits: Upper	Limits: Lower	Period Probability of Occurrence
.29	150.23	49.77	1.00
.72	227.76	-31.61	.88
1.14	344.94	-249.98	.58

Figure 4.2 --- Distribution Parameters for McLaren Generator

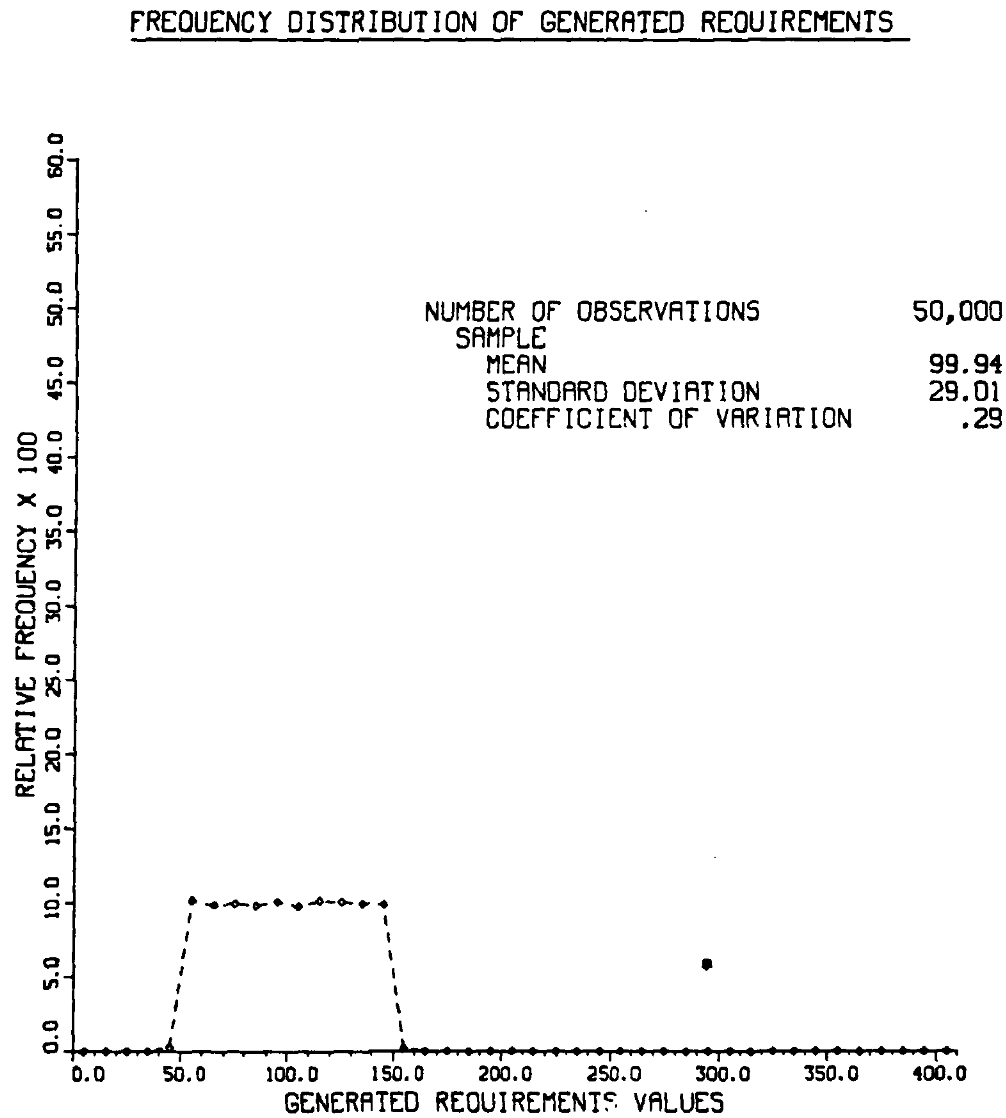


FIGURE 4.3 WEMMERLOV REQUIREMENT GENERATOR
UNIFORM DISTRIBUTION

FREQUENCY DISTRIBUTION OF GENERATED REQUIREMENTS

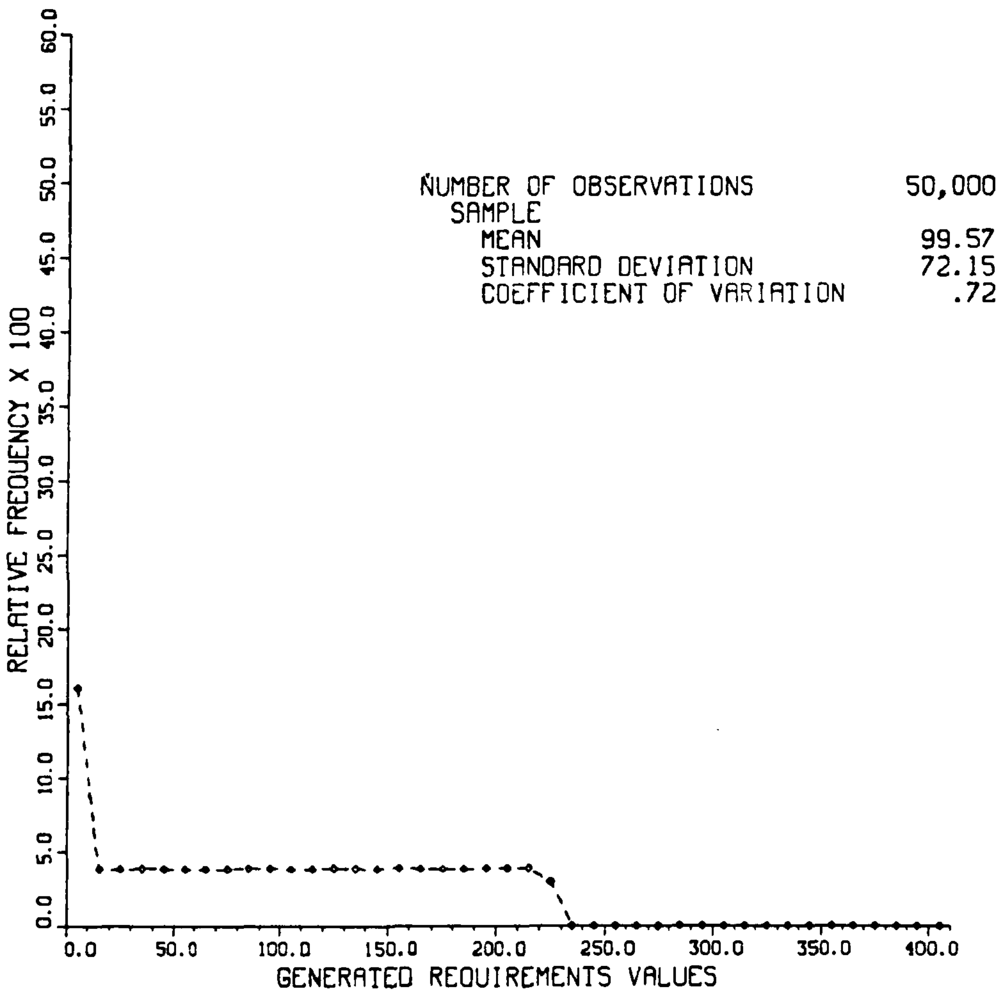


FIGURE 4.4 WEMMERLOV REQUIREMENT GENERATOR
UNIFORM DISTRIBUTION

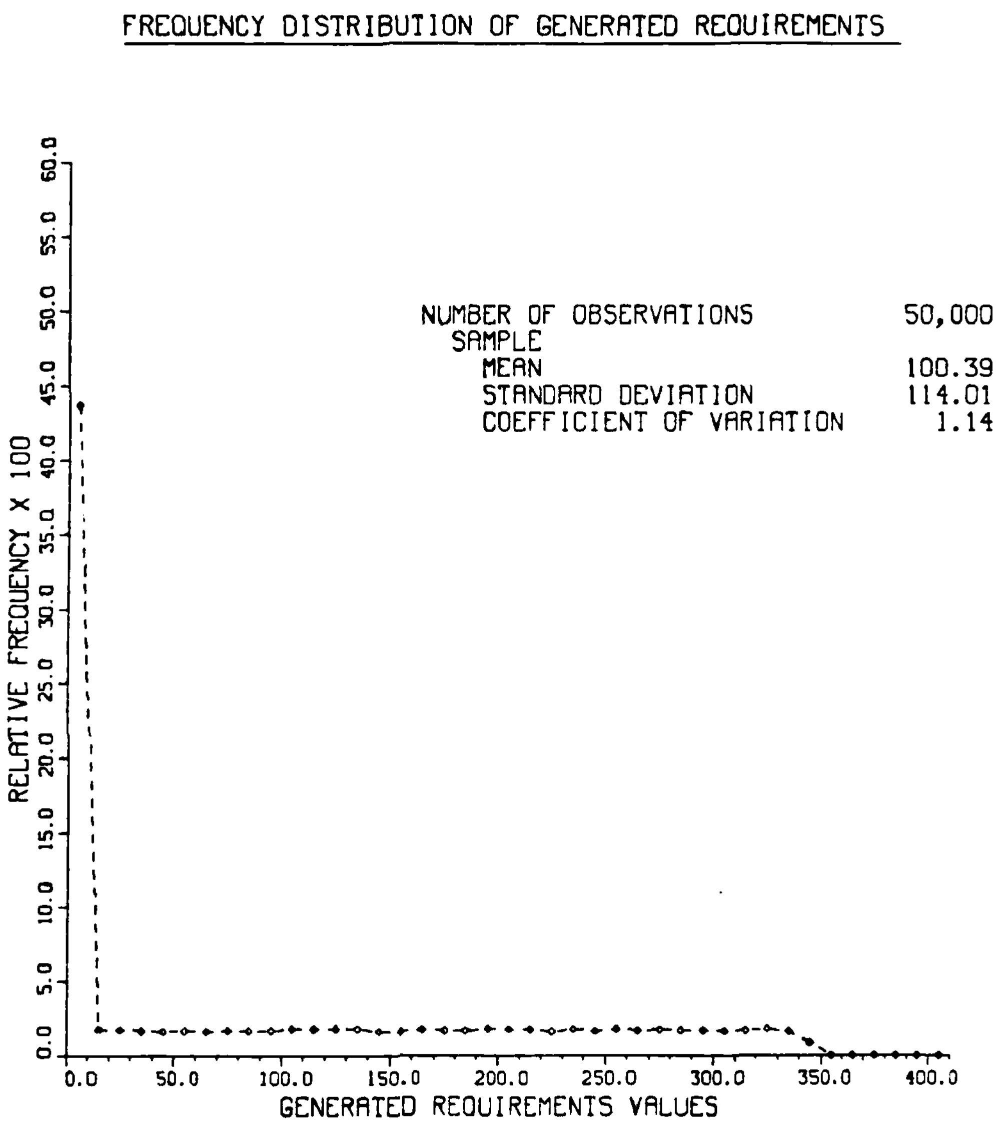
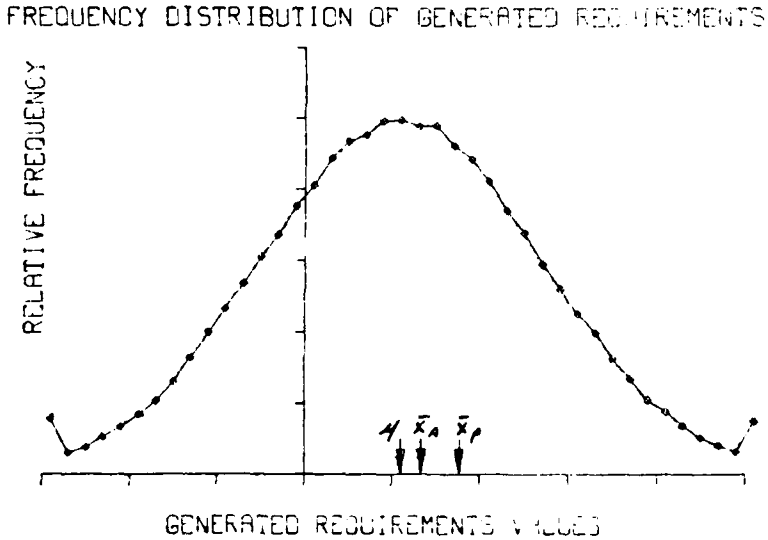


FIGURE 4.5 MCLAREN REQUIREMENT GENERATOR
UNIFORM DISTRIBUTION

The procedure used by McLaren was modeled in a Simscript simulation. For each level of the coefficient of variation used in this study, 50,000 random samples were drawn from the model. The frequency distributions of those samples are presented as histograms, with a cell width of 10 units, in Figures 4.3, 4.4 and 4.5. In addition, from each distribution, 10 vectors of 550 elements were selected for modification and experimentation as described in this chapter in the subsection titled "Grouping".

Wemmerlov

The procedure used by Wemmerlov to generate a requirements vector is based on sampling from a censored normal distribution specified by a mean and standard deviation [94]. Samples drawn from the distribution which have a value less than zero are interpreted as periods of null requirements. For a given normal distribution mean, increasing the standard deviation of the distribution has two effects. First, it increases and the mean value and decreases the standard deviation of a sample drawn from the distribution relative to the mean value of the distribution. Second, it increases the number of null periods. The general nature of the distribution to be estimated is given in Figure 4.6.



where : μ = population mean of normal distribution
$\bar{x}_A$ = sample mean including null periods
$\bar{x}_P$ = sample mean of positive periods

Figure 4.6 --- Estimation of Parameters of a Censored Normal Distribution

The objective is to estimate the population mean (μ) and standard deviation (σ) which will result in a specified coefficient of variation defined by the ratio of the sample standard deviation (S_A) divided by the sample mean ($\bar{x}_A$). Since the proportion of null periods, which determines the point of censoring, is not known, an iterative simulation

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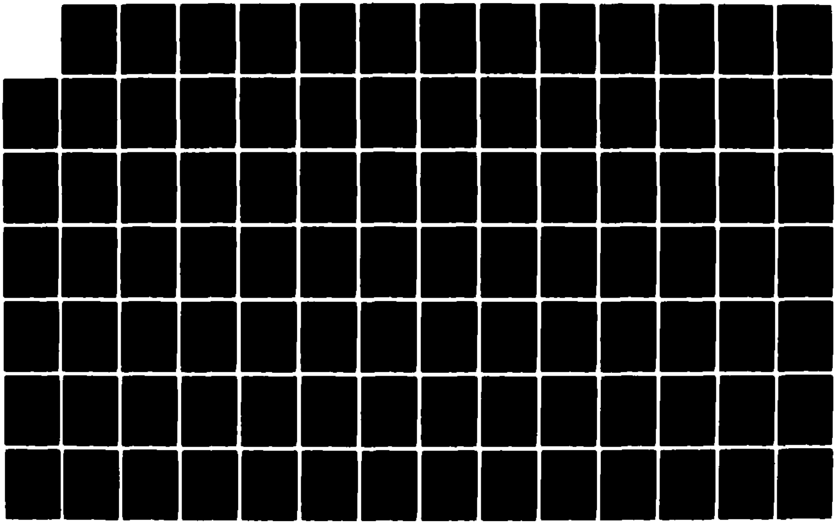

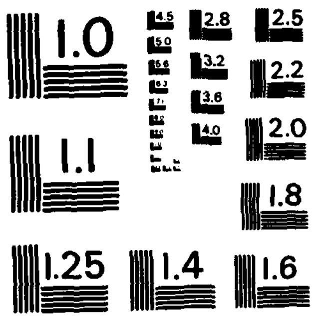

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search was performed to determine the population parameters. The parameters estimated for the Wemmerlovian model are based on a sample run of 250,000 observations and are given in Figure 4.7.

Coefficient of Variation	--- Parameters --- Mean	Standard Dev	Period Probability of Occurrence
.29	100.05	28.95	1.00
.72	95.60	79.80	.88
1.14	62.40	160.50	.65

Figure 4.7 --- Distribution Parameters for Wemmerlov Generator

As with the McLaren generator, from each of the populations estimated, 50,000 random samples were drawn to provide a frequency distribution. The histograms, with cell width of 10, are presented in Figures 4.8, 4.9 and 4.10. Ten vectors of 550 units were also drawn from each distribution for modification and experimentation.

FREQUENCY DISTRIBUTION OF GENERATED REQUIREMENTS

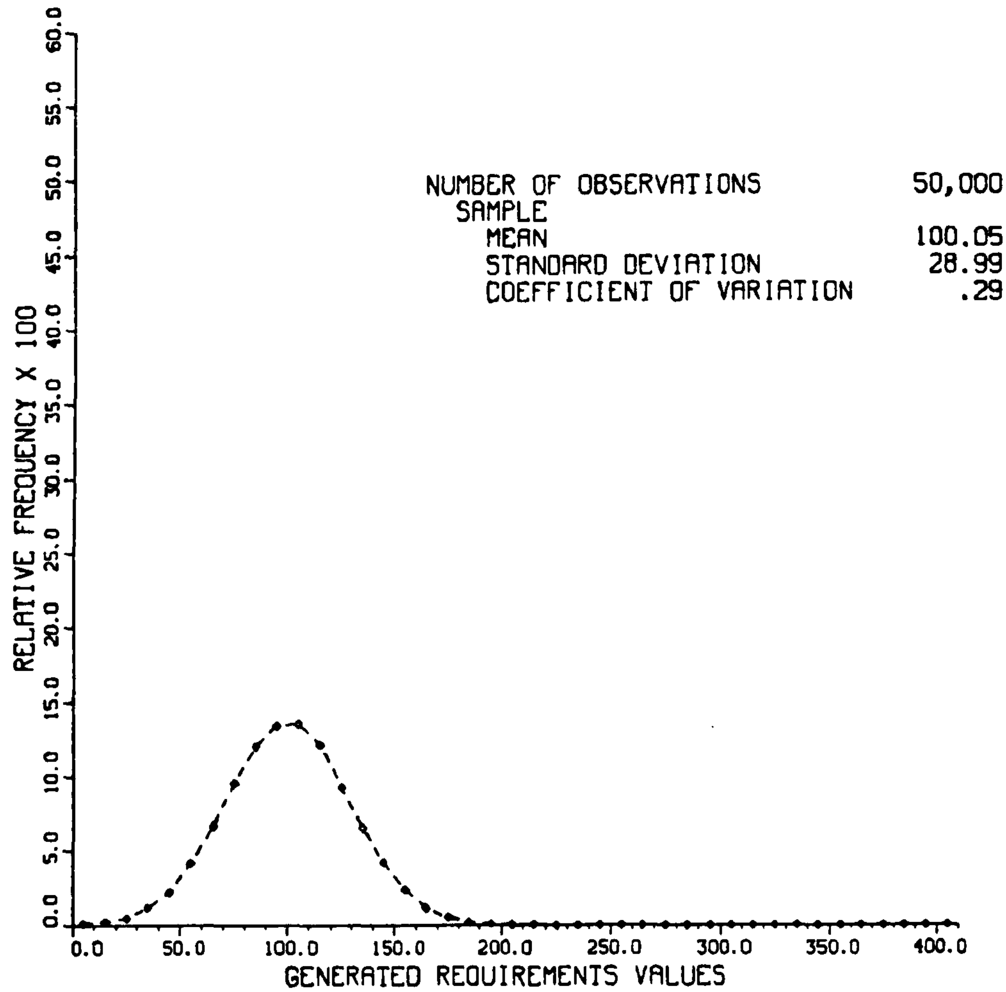

FIGURE 4.8 WEMMERLOV REQUIREMENT GENERATOR
CENSORED NORMAL DISTRIBUTION

FREQUENCY DISTRIBUTION OF GENERATED REQUIREMENTS

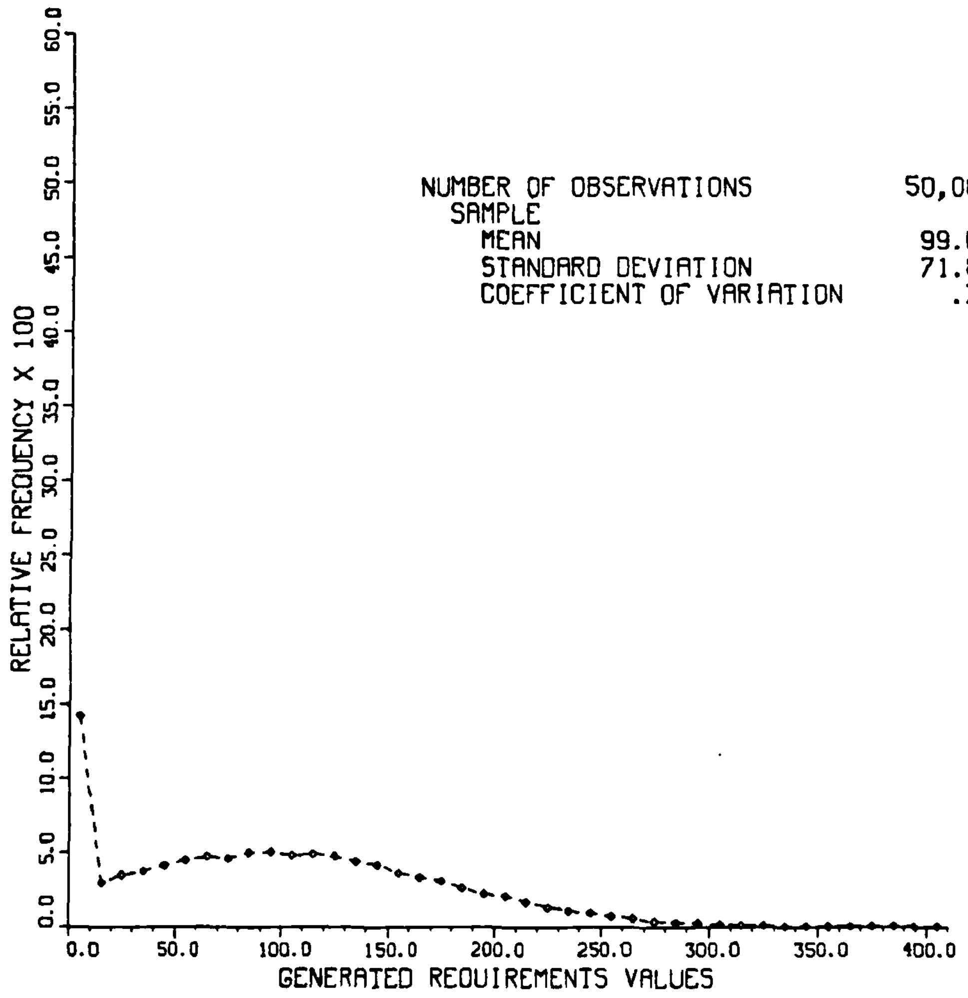

FIGURE 4.9 WEMMERLOV REQUIREMENT GENERATOR
CENSORED NORMAL DISTRIBUTION

FREQUENCY DISTRIBUTION OF GENERATED REQUIREMENTS

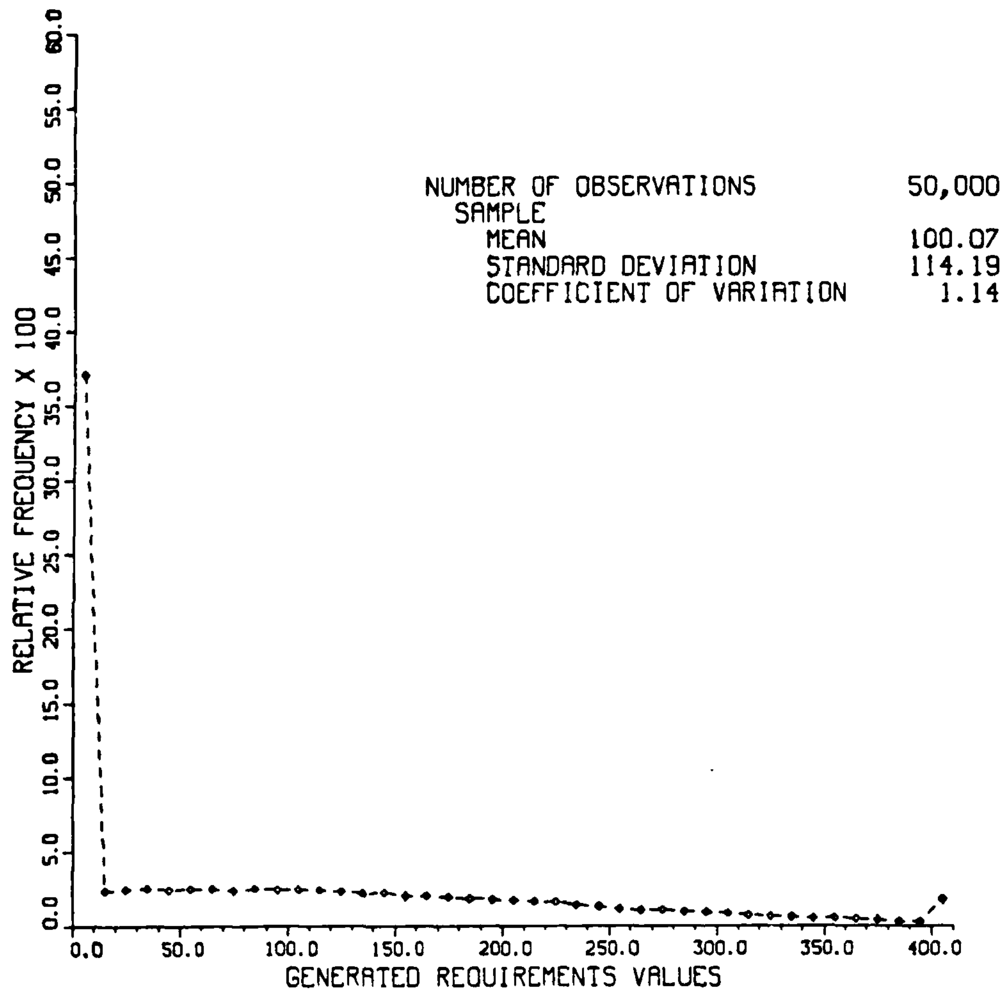

FIGURE 4.10 WEMMERLOV REQUIREMENT GENERATOR
CENSORED NORMAL DISTRIBUTION

Blackburn and Millen

The requirements generation procedure developed by Blackburn and Millen is similar to that used by Wemmerlov in that a normal distribution is used for sampling positive requirements. The Blackburn and Millen procedure differs, however, in that the probability of a null requirement in a particular period is specified. In their experiment Blackburn and Millen set the probability of a null requirement in a period at 20%. For this research the implementation of the Blackburn and Millen procedure had to be modified to maintain the same coefficient of variation and average requirement as developed using the McLaren and Wemmerlov procedures.

It is possible to obtain a specified coefficient of variation for a fixed average period demand, using the Blackburn and Millen model, by changing either the probability of a null requirement or the standard deviation of the sampled distribution. In this research, the choice was based on the minimum coefficient of variation achievable for a 20% probability of null requirements. This minimum is obtained by reducing the standard deviation of the sampled distribution to zero while maintaining a 20% probability of null requirement. The resulting mimimum coefficient of variation is 0.527.

For coefficients of variation less than 0.527, the

probability of null requirement was not specified. The experimental coefficient of variation was obtained by adjusting the standard deviation of the sampled distribution. For coefficients of variation greater than 0.527, the probability of null requirement was initially established at 20%. The standard deviation of the sampled distribution adjusted to achieve the necessary levels of coefficient of variation. Samples with negative values were interpreted as periods of null requirements. The resulting distribution parameters are given in Figure 4.11.

Coefficent of	--- Parameters ---		Period Probability
Variation	Mean	Standard Dev	of Occurrence
.29	100.05	28.95	1.00
.72	124.57	58.85	.78
1.14	106.60	140.40	.61

Figure 4.11 --- Distribution Parameters for Blackburn and Millen Generator

As with the preceding requirements generators, each of the estimated populations was sampled 50,000 times to provide a frequency distribution. The histograms, with cell width of 10, are presented in Figures 4.12, 4.13 and 4.14. Ten vectors of 550 units were also drawn from each distribution for modification and experimentation.

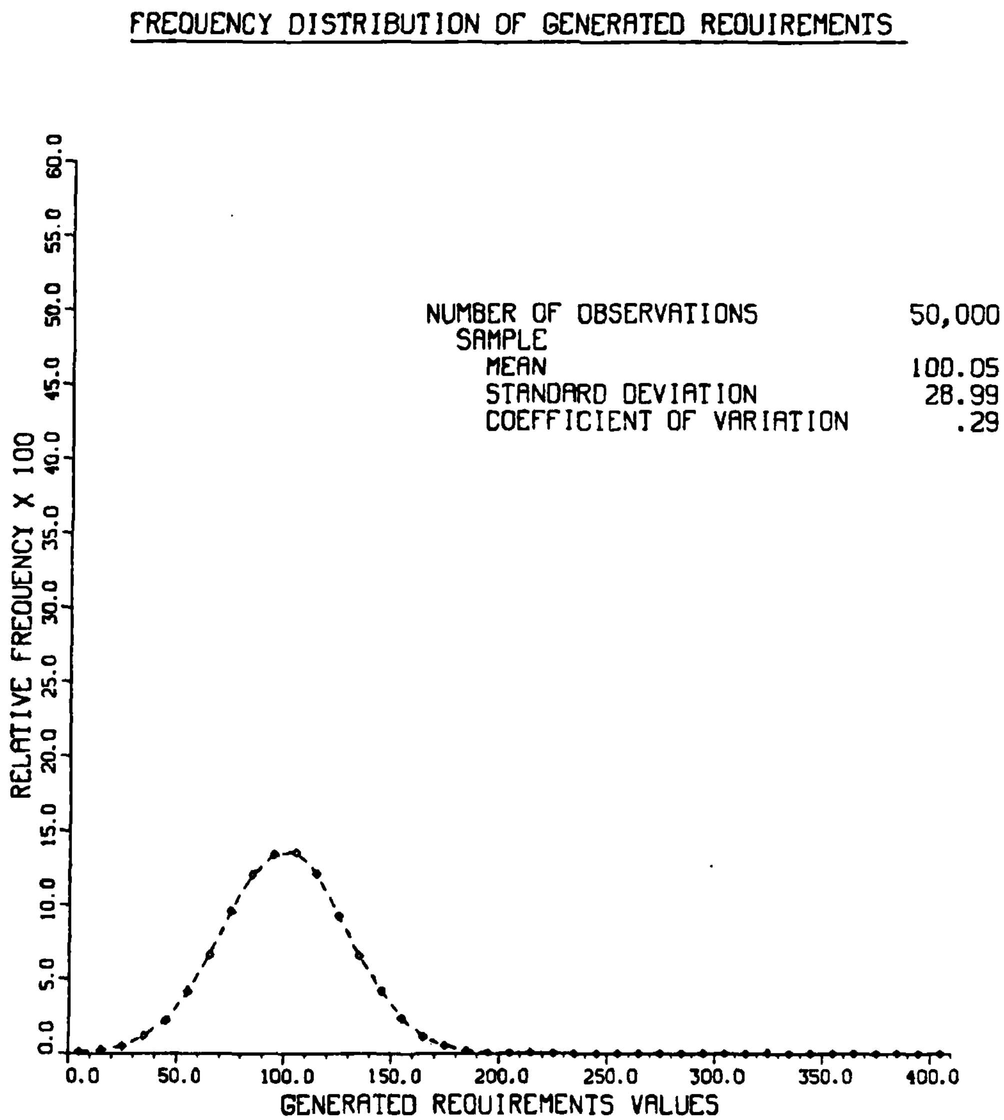

FIGURE 4.12 BLACKBURN AND MILLEN REQUIREMENT GENERATOR NULL REQUIREMENT DETERMINED BY STANDARD DEVIATION

FREQUENCY DISTRIBUTION OF GENERATED REQUIREMENTS

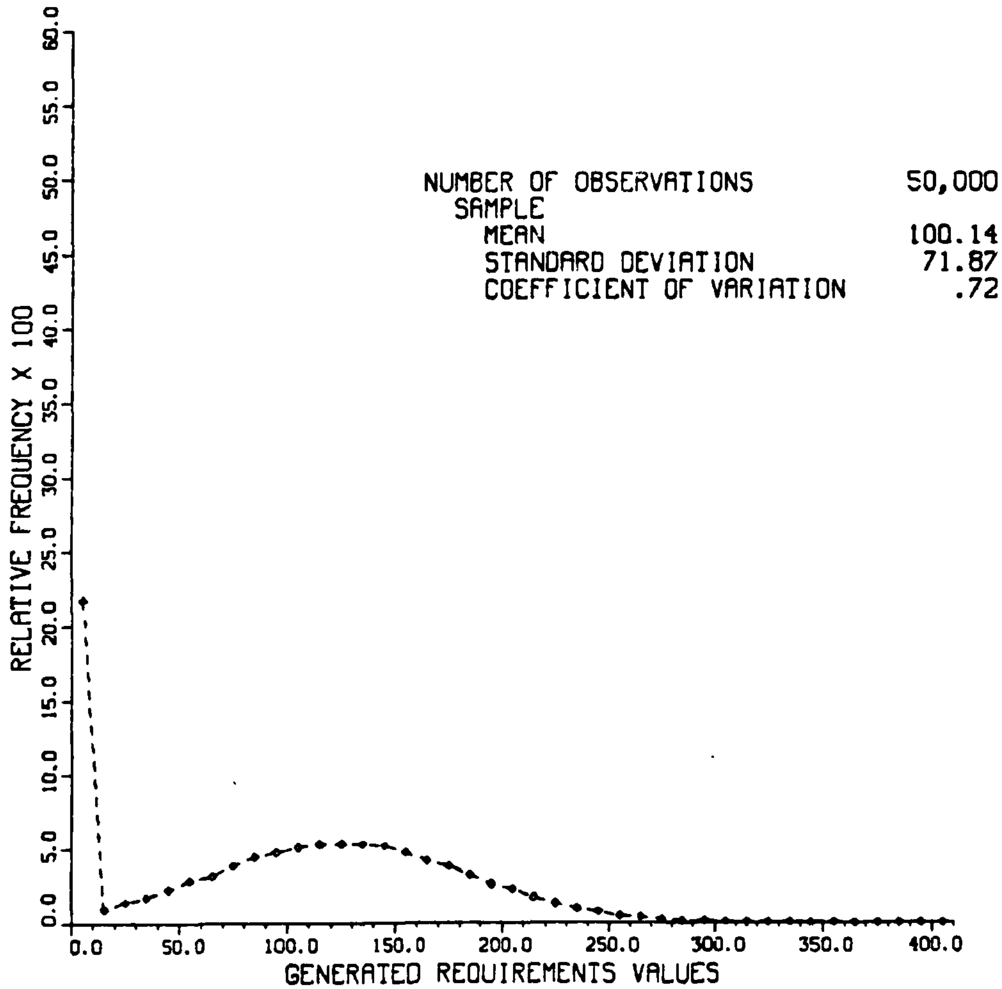

FIGURE 4.13 BLACKBURN AND MILLEN REQUIREMENT GENERATOR WITH 20 PERCENT PROBABILITY OF NO REQUIREMENT

FREQUENCY DISTRIBUTION OF GENERATED REQUIREMENTS

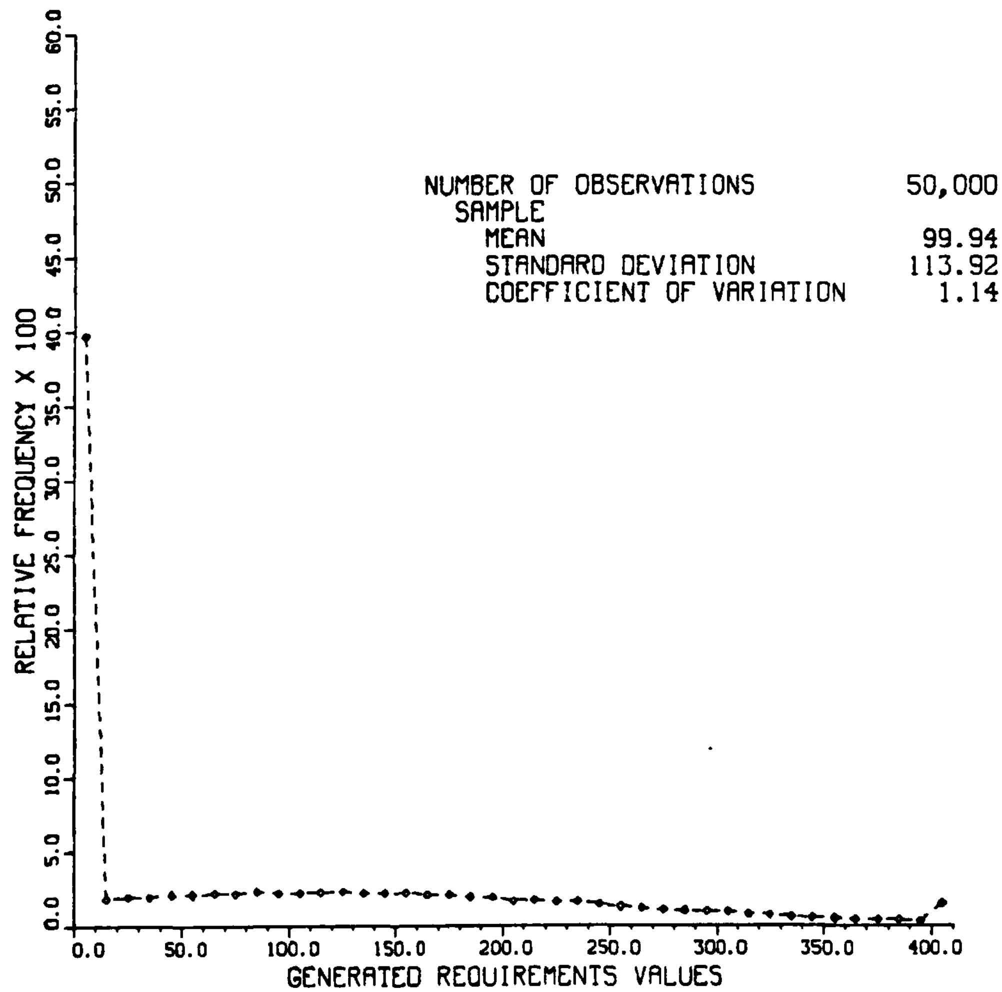

FIGURE 4.14 -BLACKBURN AND MILLEN REQUIREMENT GENERATOR WITH 20 PERCENT PROBABILITY OF NO REQUIREMENT

The above procedures resulted in a total of ninety vectors being drawn, ten from each combination of generation procedure and coefficient of variation. The Simscript II.5 program "GENE" that generated the vectors is presented in Appendix A. The specifics of each vector are presented in Appendix D. Summary statistics for each of the nine combinations of procedure and coefficient of variation are presented in Figure 4.15.

	All Periods			Positive Occurrence Periods			
		--- Values ---			Standard		
	Cv	Low	High	Mean	Deviation	Cv	Frequency
McLaren							
	.29	49.8	150.0	99.8	28.7	.29	1.00
	.72	0.0	228.0	113.8	65.6	.58	.88
	1.14	0.0	345.0	170.0	99.6	.59	.59
Wemmerlov							
	.29	0.0	201.0	100.0	29.0	.29	1.00
	.72	0.0	406.0	113.0	67.5	.60	.88
	1.14	0.0	659.0	153.5	107.5	.70	.65
Blackburn and Millen							
	.29	0.0	201.0	100.0	29.0	.29	1.00
	.72	0.0	354.0	127.0	57.6	.45	.79
	1.14	0.0	628.0	161.0	105.0	.65	.61

Figure 4.15 --- Sample Vector Summary Statistics

Grouping

In Chapter II we defined groupiness as an element of lumpiness. In this research we will address grouping in terms of the interspersion of periods with positive requirements with periods of no requirements. At this level of consideration, a vector of requirements may be represented as a sequence of 1's and 0's for occurrence and non-occurrence (null) periods respectively. Vectors 'A', 'B' and 'C', illustrated in Figure 4.16, depict a "0", "1" representation of requirements. All of the vectors have 6 null periods (0) and 6 positive periods (1), however the grouping of requirements is different.

	period												
	1	2	3	4	5	6	7	8	9	10	11	12	frequency
'A'	1	0	0	0	1	1	0	1	1	1	0	0	6
'B'	1	1	0	0	1	1	0	0	1	1	0	0	6
'C'	1	0	1	0	1	0	1	0	1	0	1	0	6

Figure 4.16 -- Characterization of Requirements Vector as Periods of Null and Positive Requirements.

The ninety original vectors generated using the procedures described in "Generating Requirements Vectors", were modified to alter the pattern of null and positive occurrences of requirements. From each of the original vectors, three new vectors were generated containing the same elements as the original vector but in a different pattern. Each of the original vectors was altered as follows:

1. A new vector, with regular spacing of null and positive periods was generated from the original vector elements. For this vector the length of each null or positive sequence of periods was set at the average null or positive run length respectively. This vector will be referred to as type 1.

2. A second new vector was created, with the original vector elements, with the null and positive run lengths adjusted by a proportional scaling factor. The scaling factor used was 2, resulting in sequences twice as long as those used in vector 1. This vector will be referred to as type 2.

3. The original vector elements were rounded to integer values. The original random spacing of null and positive occurrences was preserved. This vector will be referred to as type 3.

Figure 4.17 illustrates three altered vectors developed from an original vector generated using the Wemmerlov procedure and a coefficient of variation of 1.14. Only the first 66 of the 550 elements in that vector are shown. The null and positive sequence variation of 1 period, in Figure 4.17a and 4.17b, is due to non-integer average run lengths.

117	182	15	549	0	254	272	64	0	0	63
74	91	55	0	0	144	175	72	0	409	135
51	0	0	174	42	221	0	0	120	105	192
80	0	238	257	122	144	0	0	152	5	205
0	0	162	9	15	0	6	10	24	0	0
168	150	45	0	221	191	65	0	0	77	146

4.17a -- Minimum Interval, Regular Spacing, Between Requirements (type 1)

117	182	15	549	254	272	64	0	0	0	63
74	91	55	144	175	0	0	0	0	72	409
135	51	174	42	221	0	0	0	120	105	192
80	238	257	122	0	0	0	144	152	5	205
162	9	0	0	0	0	15	6	10	24	168
150	45	0	0	0	221	191	65	77	146	360

4.17b -- Extended Interval, Regular Spacing, Between Requirements (type 2)

0	117	182	15	0	0	549	254	272	0	64
63	74	91	0	0	0	0	55	0	144	175
0	72	409	135	51	0	174	42	221	120	0
105	0	192	0	80	238	0	257	122	0	0
144	152	0	5	0	0	0	205	162	9	0
0	15	6	0	0	10	24	0	168	150	45

4.17c -- Original Interval Between Requirements (type 3)

Figure 4.17 -- Sample Elements of Modified Requirements Vectors, Wemmerlov Procedure, Coefficient of Variation 1.14.

Summary statistics on the average positive run length and null run length are presented by altered vector type in Figure 4.18.

	Type 1		Type 2		Type 3	
Cv	Positive Mean	Null Mean	Positive Mean	Null Mean	Positive Mean	Null Mean
McLaren						
.72	8.17	1.15	15.40	2.22	8.14	1.15
1.14	2.48	1.70	4.92	3.37	2.48	1.69
Blackburn and Millen						
.72	4.65	1.27	9.16	2.51	4.65	1.27
1.14	2.52	1.61	5.01	3.23	2.52	1.61
Wemmerlov						
.72	8.59	1.15	16.60	2.25	8.59	1.15
1.14	2.81	1.54	5.55	3.06	2.81	1.53

Figure 4.18 --- Run Length Summary Statistics for Altered Vector

Lot-Sizing Procedures

Three lot-sizing procedures are used in this study. They are: the Periodic Order Quantity (POQ) procedure , the Groff (GR) procedure and the Silver - Meal (SM) procedure. Each of these procedures was described in Chapter III.

The Periodic Order Quantity procedure is the most widely implemented lot-sizing algorithm in MRP systems [91]. It is a variation of the EOQ procedure modified for use in an environment of discrete periodic requirements. The Silver - Meal Procedure has been suggested as a superior lot-sizing algorithm by Blackburn and Millen. Wemmerlov found in his comparative study that the Groff procedure "dominates SM in terms of cost efficiency, consistency and model simplicity" [94]. He further stated that the Groff procedure "seems to be the best discrete, single stage heuristic available for use in an uncapacitated environment" [94].

Time Between Orders

The order size determined by a lot-sizing procedure may be expressed either in terms of the amount that is to be ordered or the expected period of time the order will cover

requirements. An accepted measure of the time dimension is the Time Between Orders (TBO), defined as :

$$\begin{aligned} TBO &= \frac{EOQ}{d} \\ &= \sqrt{\frac{2\ Co}{d\ Ch}} \\ &= \sqrt{\frac{2\ R}{d}} \end{aligned} \qquad (4.3)$$

where:

EOQ = Economic Order Quantity
d = Average period demand
Co = Cost of placing an Order
Ch = Period holding cost
R = Co/Ch

Given a constant demand, TBO will vary as the square root of the ratio of setup to holding cost. As R increases, the TBO also increases, implying a larger order size to cover the longer order interval. Holding all factors constant, TBO provides a relative measure of the frequency of placing orders. A non-integer TBO suggests that some portion of an order will be carried as inventory from period to period. Two TBOs (2.0, 4.90) were selected for this study to investigate the interaction of the number of periods an order would cover and the grouping of requirements. The levels selected are consistent with previous comparison studies in the literature. [7,39,94]

For all experiments, the average period requirement and holding cost were held constant at 100 and 2 respectively. The order cost for each TBO, stated as a function of the average period requirement and holding cost is given by:

$$Co = Ch * (d/2) * TBO^2 \qquad (4.4)$$

Simulation Model

The simulation model used in this study is written in Simscript II.5 and is titled "CUKY2". A complete listing of the program is contained in appendix C. CUKY2 incorporates the Simscript II.5 modelling concepts of entities, attributes and sets. Individual time periods ("time buckets") are represented as temporary entities which have attributes that include: expected requirements, planned order receipts, planned order releases and expected on-hand balances. In the current running of the model, all expectations are realized resulting in no uncertainty. These temporary entity time periods are members of a set of time periods, which is referred to as a schedule.

Throughout the operation of the model, events are scheduled which may revise entity attributes. These events include the initialization of entities before each replication run, the occurrence of a requirement, the receipt of an order and the collection of system operating statistics. In addition to events, routines in the model

perform specific sets of operations.

Assumptions

The following assumptions were made in the simulation model:

1. Demand occurs in discrete time periods of equal duration over the planning horizon.
2. Replenishment opportunities are limited to the beginning of time periods.
3. Forecast requirements are accurate and included no error.
4. Initial on-hand inventory is zero.
5. Lead time for orders is known, constant and fixed at 1 period.
6. Once an order is scheduled it will arrive on time.
7. An order is delivered in its entirety and at the same time.
8. The planning horizon for future requirements is 50 periods.
9. No provision for backordering is necessary.
10. Demand occurs uniformly within time periods.

Verification/Validation

Since there is some confusion in the use of the terms verification and validation in the literature, the following definitions offered by Law [56] will provide the basis for the following discussion. Verification is determining whether the model performs as intended. Validation is determining whether a simulation model is an accurate

representation of the real world system under study.

The verification of "CUKY2" was undertaken as a process during the development of the simulation program. To implement the process the following procedures were followed:

1. The simulation model was developed with each major process represented as an individual module. These modules were individually tested with known data to assure correct operation. For example, each lot-sizing procedure is contained in a separate module which has been tested for correct operation against examples in the literature.

2. The assembled model was also tested against examples in the literature. In addition, the model was tested under simplified assumptions, the results of which were confirmed by hand calculation.

3. The model was developed with the capability of printing out formatted period data on requirements, on-hand balances, planned order receipts and planned order releases. Using this capability, selective traces of operations and calculations were performed for chronological sequence of events. Intermediate results were fully documented. These traces were performed at preselected intervals throughout representative run lengths.

Validation may be considered the process of building an acceptable level of confidence that the correspondence of simulated data and real data is close enough that an inference about the simulated data is a valid inference about the actual system. The simulated model is only an approximation of the real system. [78]

To confirm the validity of the model the following issues were considered:

1. Face validity. In conversations and correspondence with experts, it was ascertained that on the surface the model seemed reasonable to people knowledgable about the operation of the simulated system.

2. Existing theory. The model uses distributions which have been suggested in the literature and lot-sizing procedures which are used in practice and documented in the literature.

3. Internal relationships. The relationships within the model are consistent and move in the same direction. For example the model will not generate an order for a negative quantity.

4. External relationships. The model is consistent with regard to external parameter changes. An increase in the cost of placing an order will result in a higher total cost, all other factors remaining constant.

Run Length and Startup Conditions

This study is a steady state simulation which defines total cost as the measure of performance as the length of the simulation approaches infinity. Of interest is a comparison of factors after the system has been running long enough so that the initial and terminating conditions of the simulation run have a minimal effect on the results obtained.

In a previous comparison study, Benton [7] found that estimates of the differences in total costs of lot-sizing procedures tended to stabilize after a run length of approximately 400 time periods. In his study, Benton excluded the information from the first 30 time periods,

because of the inclusion of uncertainty, and extended the run length to 450 periods. In this study, the run length is 540 periods. Data is collected the first 500 periods.

A related subject is the selection of starting conditions for the simulation. Shannon [78] suggests three possible techniques for minimizing the biasing effects of the initial transient periods:

1. Use long enough computer runs to reduce the relative importance of the transient periods.
2. Exclude an initial portion of the run.
3. Choose starting conditions typical of steady state conditions.

In this study, technique 1 was selected and the system was started with no on-hand inventory balance.

The results of the simulation runs were compared under identical conditions. Specifically, identical requirements vectors, generated using the previously described procedures, were used for each replication of a given combination of factors. In the analysis of data, the differences between observations were used to remove the dependency between observations resulting from the use of the identical requirements vectors.

The Relative Precision of Sample Means

A trial experiment of ten simulation runs was conducted with each factor held at a fixed level. The results of the experiment were:

Run	Total Cost
1	499548
2	499095
3	500940
4	499049
5	501094
6	498810
7	497772
8	501969
9	504218
10	497797

The objective of this trial experiment was to estimate the population variance and establish the relative precision of the 95% confidence interval constructed about the expected value of the sample. "The relative precision is a measure of how precisely we know u. [56]

The 95% confidence interval for u may be computed as:

$$\bar{X}(n) \pm t_{n-1,1-\alpha/2} \sqrt{s^2(n)/n}$$

where: $\bar{X}(n) = \sum_{i=1}^{n} X_i / n$

$s^2(n) = \sum_{i=1}^{n} [X_i - \bar{X}(n)]^2 / (n-1)$

$t_{n-1,1-\alpha/2}$ = upper $1-\alpha/2$ critical point of a t distribution with n-1 degrees of freedom

The quantity :

$$\delta = t_{n-1}\ ,_{1-\alpha/2}\sqrt{s^2(n)/n}$$

is called the half-length (h.l.) of the confidence interval. The relative precision (γ) of the confidence interval is the ratio of the half length to the point estimate (sample mean).

$$\gamma = \frac{\delta}{\bar{X}(n)}$$

The computations for the relative precision for the trial experiment are:

$$\bar{X}(10) = 50027.8$$

$$s^2(10) = 4093845.8$$

$$t_{9,.05} = 1.833$$

$$P\ \{\ 498855.0 < \bar{x}(10) < 501200.6\ \} = .95$$

$$\gamma = .002$$

This high relative precision confirms the adequacy of ten replications for each combination of factors used in the experiments.

Experimental Design

The experimental design used in this study is a full factorial ANOVA model with 10 replications in each cell. The factors and levels used in the model are: coefficient of variation (Cv), 3 levels; lot-sizing algorithm (LS), 2

levels; time between orders (TBO), 2 levels; generation procedure (GEN), 3 levels; Grouping (Gp), 3 levels. The response variable used in the model is the relative total inventory cost difference between the selected lot sizing algorithm, and the Groff algorithm. For any algorithm (A) the relative total cost is:

$$Reltc = \left(\frac{TCa - TCg}{TCg}\right) 100 \qquad (4.5)$$

where:

Reltc = Relative Total Cost

TCa = Total Inventory Cost for Requirements Vector (i) using:

$$a \left\{ \begin{array}{l} \text{[Periodic Order Quantity Algorithm]} \\ \\ \text{[Silver-Meal Algorithm]} \end{array} \right\}$$

TCg = Total Inventory Cost for Requirements Vector (i) using Groff Algorithm

There are (3 X 2 X 3 X 3) = 54 sample problems. Each sample problem was run with 3 lot-sizing procedures and replicated 10 times for a total of 1620 sample data points.

Research Hypothesis

The primary objective of this study is the investigation of the coefficient of variation as an adequate measure of a requirements vector. The environment in which the issue of adequacy is important is in the selection of a lot-sizing algorithm. The first major hypothesis, therefore, involves investigating the significance of

environmental factors on the relative total cost performance of selected lot-sizing algorithms. It is anticipated that the generation technique used to develop a requirements vector and the lumpiness of that vector will be significant factors in determining the relative cost performance. It is further anticipated that a model that includes lumpiness and grouping factors will provide improved results over a model that does not include those factors. Formally the hypotheses may be stated as:

HO(I) The experimental Factors have no effect on the relative total cost of selected lot-sizing procedures. In particular,

- HO(Ia) The coefficent of variation has no effect on relative total cost.
- HO(Ib) The lot-sizing procedure has no effect on relative total cost
- HO(Ic) The time between orders has no effect on relative total cost
- HO(Id) The generation procedure used has no effect on relative total cost
- HO(Ie) The grouping pattern of a requirements in a vector has no effect on relative total cost

The second area of interest is whether the inclusion of the generation technique and grouping factors results in a "better" set of independent variables. In particular, is the inclusion of the additional independent variables worthwhile ?

Chapter V presents the results and analysis of the formal simulation experiments.

CHAPTER V

EXPERIMENTAL ANALYSIS

In Chapter IV we developed a methodology for evaluating the coefficient of variation as an adequate descriptor of a requirements vector. To carry out the formal experiments, a Simscript II.5 computer simulation program was developed to execute the ordering logic sequence and accumulate data on the operation of the system. That program, "CUKY2", was described in chapter IV and is contained in Appendix C. This chapter presents a discussion and analysis of the results of the simulation experiments.

The analysis of the experimental data was accomplished in three phases. The first phase was a five-way analysis of variance (ANOVA) using the Statistical Package for the Social Sciences (SPSS). The purpose of the first phase was to analyze all main effects and interactions of factors. The second phase of the analysis was a three-way ANOVA which excluded the generation procedure (GEN) and grouping (GP) factors from the ANOVA model. This phase addressed the question of whether the inclusion of the additional factors for grouping and generation procedure, resulted in a

"better" set of independent variables. The third phase of the analysis is a discussion of mean cell responses for selected factor levels.

Analysis of Experimental Hypothesis

The first test of the experimental data was a five factor ANOVA with third order and higher interactions surpressed. The results of the ANOVA are presented in Table 5.1 as main and interaction effects. The primary hypothesis that the experimental factors have no effect on the relative total cost of selected lot-sizing procedures was rejected at an alpha level of .01. In the following section we shall use mean relative total inventory cost to discuss the main effect for each factor. Table 5.2 contains the overall mean relative total inventory cost value for each factor by level of that factor. In a subsequent section we will address interaction effects.

Main Effects

All of the main effects were found to be statistically significant at an alpha level of .01. These effects are presented in Figure 5.1 as a composite graph. On that graph each factor is identified on the abcissa. Ordinate values are relative total inventory cost and are the same scale for each graph. In interpreting that figure and all subsequent

Factor Effects (Source of Error)	F	Level of Significance
Main Effects		
Coefficient of Variation (Cv)	1092.273	.001
Generation Procedure (GEN)	22.605	.001
Grouping (GP)	17.651	.001
Lot-Sizing (LS)	7273.976	.001
Time Between Orders (TBO)	142.730	.001
Interactions		
CV by GEN	34.420	.001
CV by GP	21.321	.001
CV by LS	824.100	.001
CV by TBO	6.006	.003
GEN by GP	.470	.758
GEN by LS	22.517	.001
GEN by TBO	5.863	.003
GP by LS	25.493	.001
GP by TBO	15.479	.001
LS by TBO	35.853	.001
MSE	2.186	

Table 5.1 --- Five-way Analysis of Variance Results

figures, it is noted that only the end points of each line segment represent actual measured data values. The lines themselves only serve to indicate the change in relative total inventory holding costs between levels of factors. It is also noted that the straight lines do not indicate a linear relationship. No attempt has been made to estimate

Coefficient of Variation	
.29	1.32
.72	3.74
1.14	5.60
Generation Procedure	
McLaren	3.63
Blackburn & Millen	3.22
Wemmerlov	3.82
Grouping	
type 1	3.30
type 2	3.85
type 3	3.51
Lot-Sizing	
Periodic Order Quantity	6.75
Silver-Meal	.36
Time Between Orders	
2.0	3.11
4.9	4.00

Table 5.2 ---- Overall Mean Relative Total Inventory Cost by Factor Level

relative total inventory costs at levels other than those specified in the research design.

The residual term of the ANOVA model had more than 9 times as many degrees of freedom as the explained variation term, indicating that an adequate number of data points were available to produce a high degree of confidence in the results.

MAIN EFFECTS

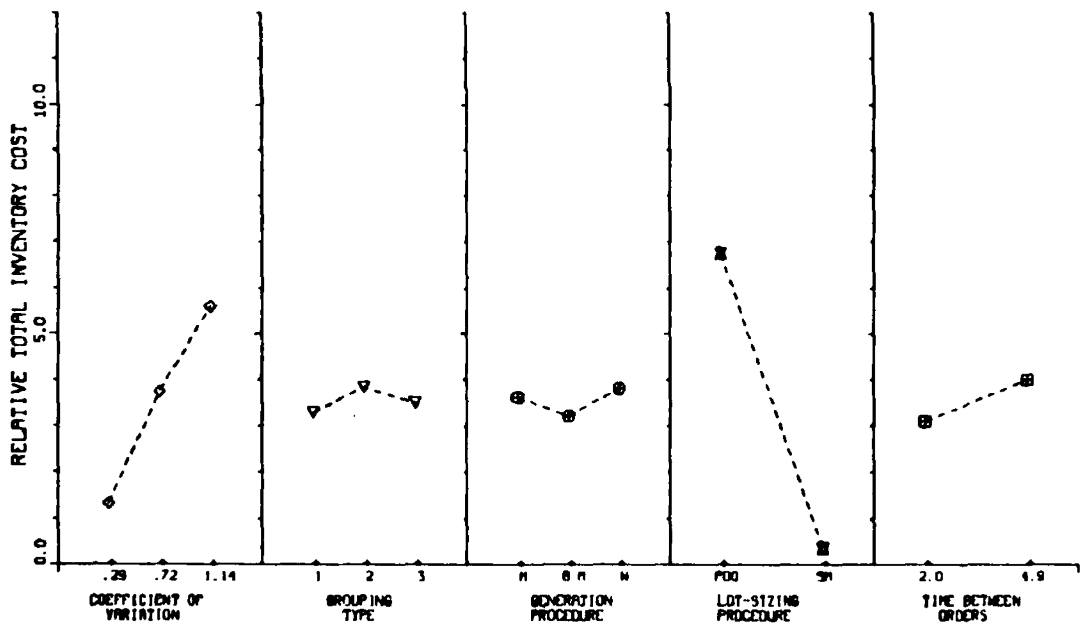

FIGURE 5.1 - MAIN EFFECTS FOR COEFFICIENT OF VARIATION, GROUPING TYPE, GENERATION PROCEDURE, LOT SIZING PROCEDURE AND TIME BETWEEN ORDERS

The individual main effects and subhypotheses are considered in the following section.

> HO(Ia): The coefficient of Variation has no effect on relative total inventory cost.

The above hypothesis was rejected. The coefficient of variation was a very significant factor in determining the relative total inventory cost. As the coefficient of variation increases, the relative advantage of using the Groff procedure over one of the other lot-sizing procedures also increases.

> HO(Ib): The lot-sizing procedure has no effect on relative total cost.

The above hypothesis was rejected. The relative total inventory cost of using the Silver-Meal (SM) procedure was statistically different than using the periodic order quantity (POQ) procedure. This finding is consistent with the findings of Wemmerlov that good rules are consistently good in various environments [94].

> HO(Ic): The Time Between Orders has no effect on relative total inventory cost.

The above Hypothesis was rejected. As illustrated in Figure 5.1, as the time between orders increases, the relative total inventory cost also increases. This result indicates that as the average number of periods covered by an order increase, the relative advantage of using the Groff procedure also increases.

HO(Id): The generation procedure used has no effect on relative total inventory cost.

The above hypothesis was rejected. This rejection indicates that at least one generation procedure is associated with a relative total inventory cost that is significantly different that the other procedures. Of the three generation procedures tested, the Blackburn and Millen procedure has the lowest relative total inventory cost followed by the McLaren procedure. The Wemmerlov procedure is associated with the largest relative total inventory cost.

HO(Ie): The grouping pattern of requirements has no effect on relative total inventory cost.

The above hypothesis was rejected. At least one of the grouping patterns was associated with a relative total inventory cost that was significantly different from other grouping patterns. In increasing order of relative total inventory cost, the patterns were: type 1 (regular, minimal length sequences of null and positive requirements), type 3 (random sequence lengths) and type 2 (regular, extended length sequences of null and positive requirements).

Interaction Effects

The following two-way interactions were found to be statistically significant:

1. Coefficient of variation vs. generation procedure

2. Coefficient of variation vs. grouping
3. Coefficient of variation vs. lot-sizing
4. Coefficient of variation vs. time between orders
5. Generation procedure vs. lot-sizing
6. Generation procedure vs. time between orders
7. Grouping vs. lot-sizing
8. Grouping vs. time between orders
9. Lot-Sizing vs. time between orders

These interactions are discussed next.

The interaction between the coefficient of variation and the generation procedure used to develop a requirements vector is shown in Figure 5.2. As illustrated on that graph, higher coefficients of variation result in higher levels of relative total inventory cost for all generation procedures. The increase in relative costs for increasing coefficient of variation values are similar for generation procedure 1 (McLaren) and procedure 3 (Wemmerlov). Procedure 2 (Blackburn & Millen) has a smaller increase in relative cost between a coefficient of variation of .29 and .72 than there is between .72 and 1.14. This departure of the Blackburn and Millen procedure from the other procedures may be explained in terms of the modifications to the procedure, explained in Chapter IV which were necessitated by experimental requirements. At the .72 coefficient of variation level, the modifications were minimal.

INTERACTION EFFECTS

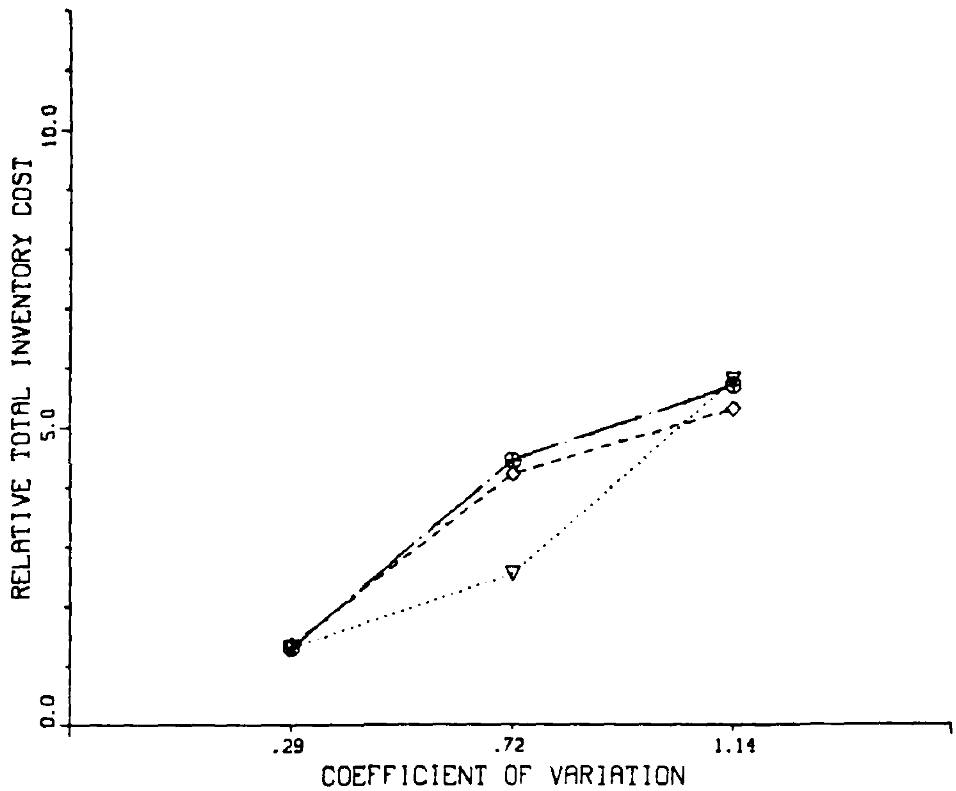

FIGURE 5.2 RELATIVE TOTAL COST AS A FUNCTION OF COEFFICIENT OF VARIATION AND GENERATION PROCEDURE

LEGEND
◇ - MCLAREN GENERATOR
▽ - BLACKBURN AND MILLEN GENERATOR
⊕ - WEMMERLOV GENERATOR

INTERACTION EFFECTS

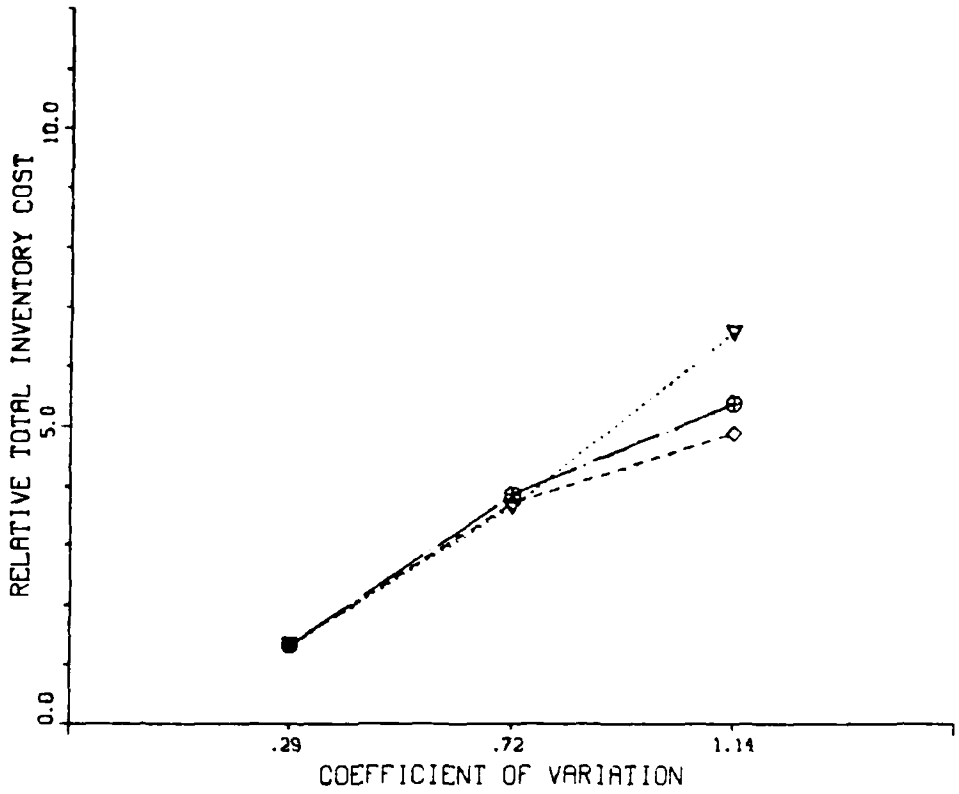

FIGURE 5.3 RELATIVE TOTAL INVENTORY COST AS A FUNCTION OF COEFFICIENT OF VARIATION AND GROUPING PATTERN

LEGEND

◇- TYPE 1 (REGULAR, MINIMUM SEQUENCES)
▽- TYPE 2 (REGULAR, SCALED SEQUENCES)
⊕- TYPE 3 (ORIGINAL SEQUENCES)

The interaction between coefficient of variation and the grouping pattern is illustrated in Figure 5.3. For a coefficient of variation of .29, there is no difference in relative costs associated with grouping patterns since a requirement occurs each period. As the coefficient of variation increases, the number of null periods in a requirements vector and the effect of the grouping pattern also increase. At a coefficient of variation of 1.14, the effect of grouping patterns is most evident. A regular pattern of null and positive requirement sequences, scaled to twice minimum length, results in the highest relative total inventory cost. The next highest is the original sequence of requirements followed by the regular, minimal spacing grouping.

The most significant interaction effect is between the coefficient of variation and lot-sizing procedure. This relationship is graphically depicted in Figure 5.4. In all cases the SM procedure resulted in lower relative total inventory costs. In addition, for increasing values of the coefficient of variation, the change in relative total inventory costs was much greater for the POQ procedure than for the SM procedure.

INTERACTION EFFECTS

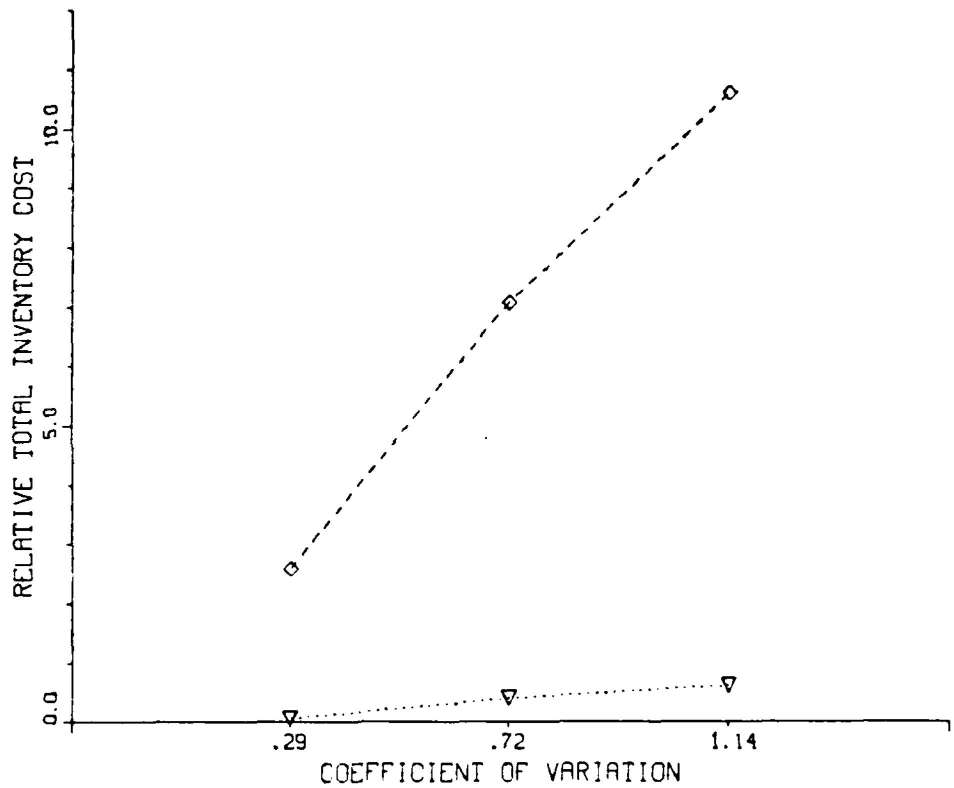

FIGURE 5.4 RELATIVE TOTAL INVENTORY COST AS A FUNCTION OF COEFFICIENT OF VARIATION AND LOT-SIZING PROCEDURE

LEGEND
◇ - PERIODIC ORDER QUANTITY
▽ - SILVER-MEAL

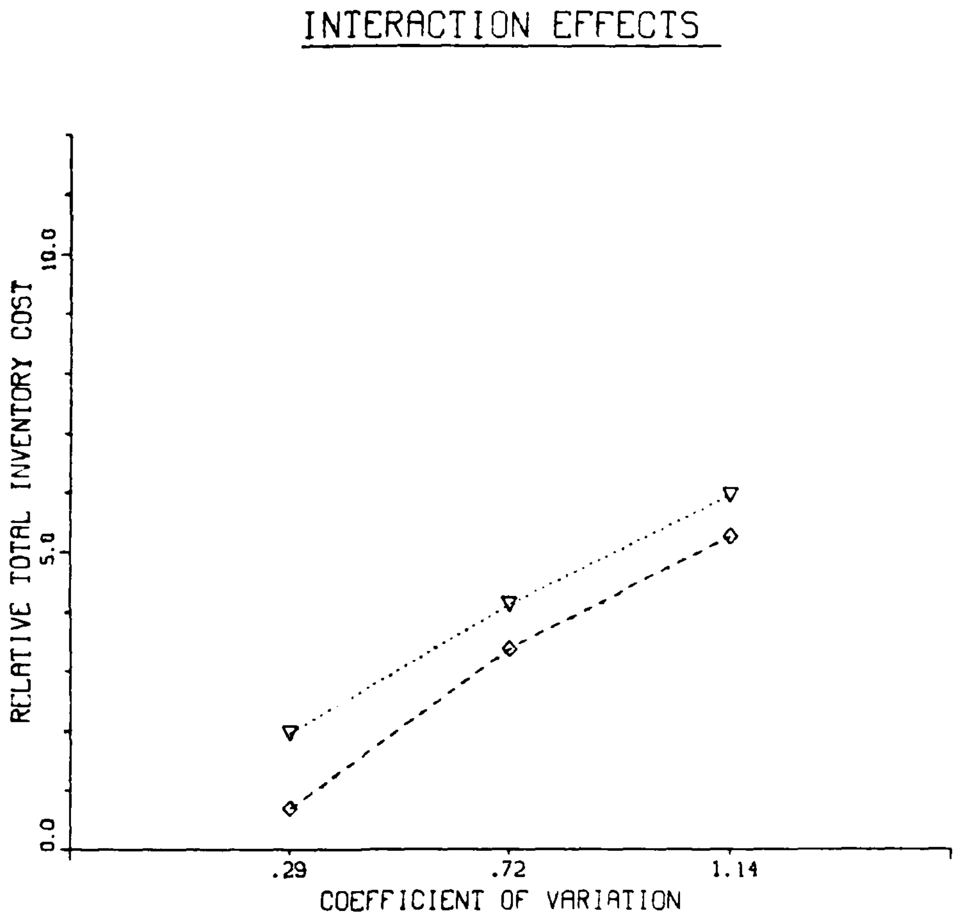

FIG 5.5 RELATIVE TOTAL INVENTORY COST AS A FUNCTION OF COEFFICIENT OF VARIATION AND TIME BETWEEN ORDERS

LEGEND
◇ - TIME BETWEEN ORDERS - 2.0
▽ - TIME BETWEEN ORDERS - 4.9

The interaction between the coefficient of variation and time between orders is not an especially strong one. As illustrated in Figure 5.5, the difference in relative total inventory cost is slightly greater for a coefficient of variation of .29 than for a coefficient of variation of .72 or 1.14.

The interaction between generation procedure and lot-sizing algorithm is presented in Figure 5.6. For each generation procedure, the SM procedure has a significantly lower relative total inventory cost than the POQ procedure. It is also apparent that while the effect of lot sizing procedure on relative total cost is large, it is smallest for the Blackburn and Millen generation procedure.

The least significant interaction is between the procedure used to generate requirements and the time between orders. For all generation procedures, there is a small increase in relative total inventory costs for a relatively large (2.0 to 4.9) change in time between orders. The Wemmerlov and Mclaren procedures have similar increases while the Blackburn and Millen generation procedure has a slightly larger increase. Figure 5.7 illustrates this relationship.

INTERACTION EFFECTS

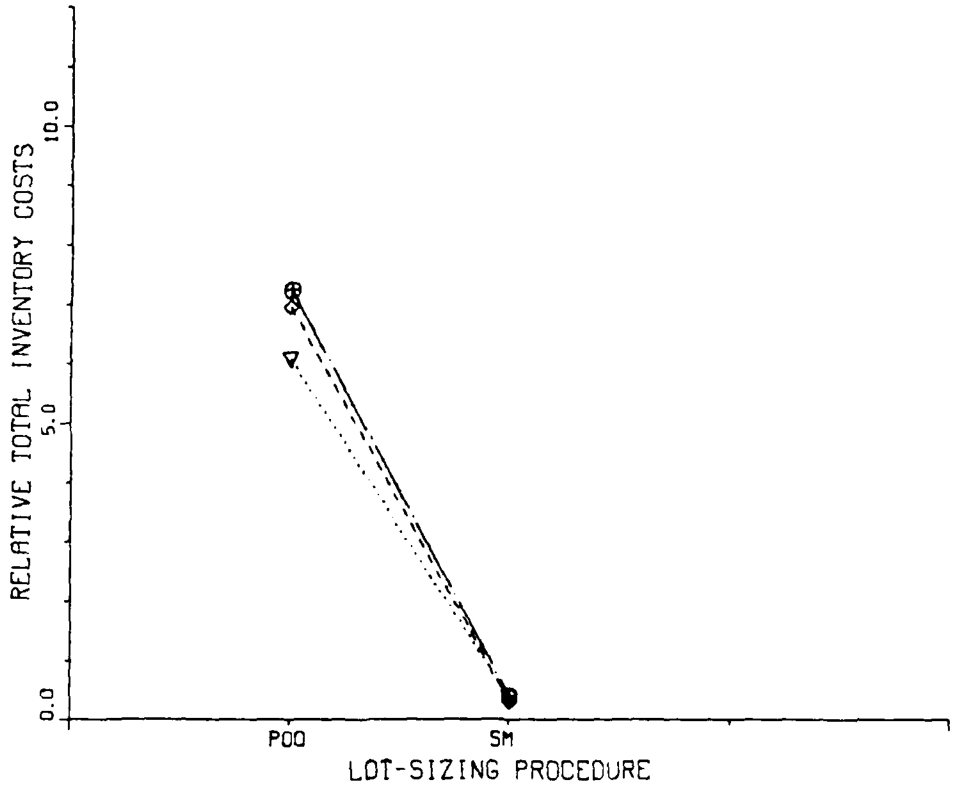

FIGURE 5.6 RELATIVE TOTAL INVENTORY COSTS AS A FUNCTION OF LOT-SIZING PROCEDURE AND GENERATION PROCEDURE

LEGEND

◇- MCLAREN GENERATOR
▽- BLACKBURN AND MILLEN GENERATOR
⊕- WEMMERLOV GENERATOR

INTERACTION EFFECTS

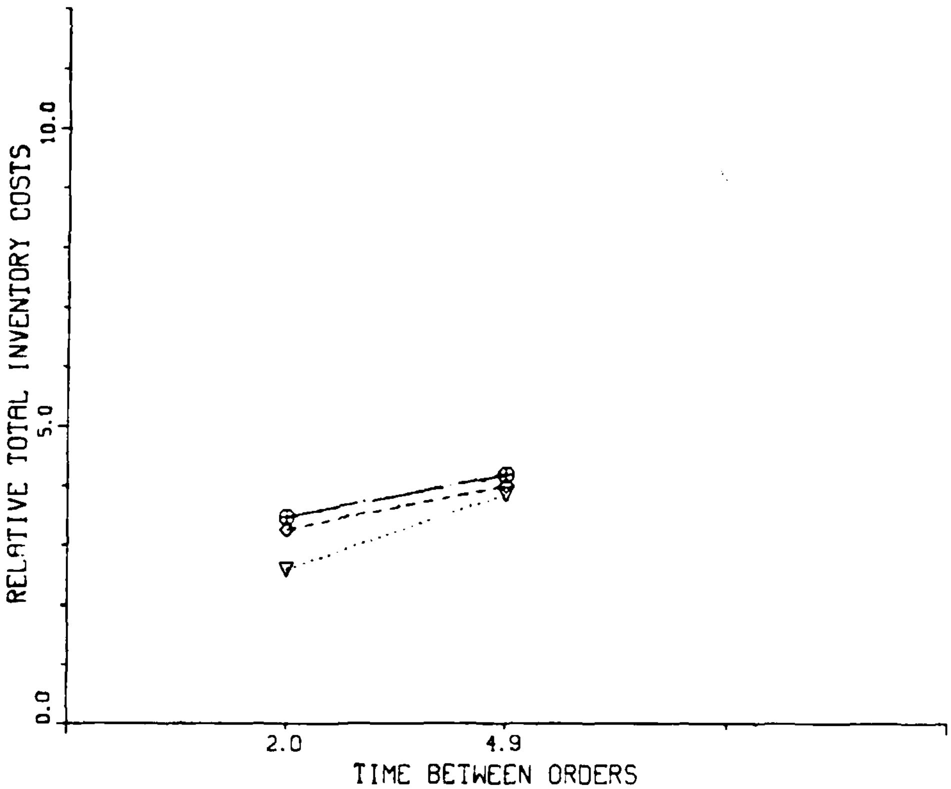

FIGURE 5.7 RELATIVE TOTAL INVENTORY COSTS AS A FUNCTION OF TIME BETWEEN ORDERS AND GENERATION PROCEDURE

LEGEND
◇- MCLAREN GENERATOR
▽- BLACKBURN AND MILLEN GENERATOR
⊕- WEMMERLOV GENERATOR

The interaction of grouping patterns and lot-sizing procedures is presented in Figure 5.8. Again the SM procedure results in a lower relative total inventory cost than does the POQ procedure. The effect of lot-sizing procedure on relative total inventory costs is not constant among all the grouping patterns. Type 2 grouping (regular, scaled sequences) has the largest change in costs for different lot-sizing procedures. The grouping pattern also interacts with time between orders as illustrated in Figure 5.9. This interaction is again most pronounced for the type 2 grouping pattern.

The interaction between lot lot-sizing procedure and time between orders is shown in Figure 5.10. For both time between orders intervals considered, the relative total inventory cost is significantly greater for the POQ procedure than for the SM procedure. While both procedures have increased relative total inventory costs for increased time between orders intervals, the increase is greater of the POQ procedure than for the SM procedure.

INTERACTION EFFECTS

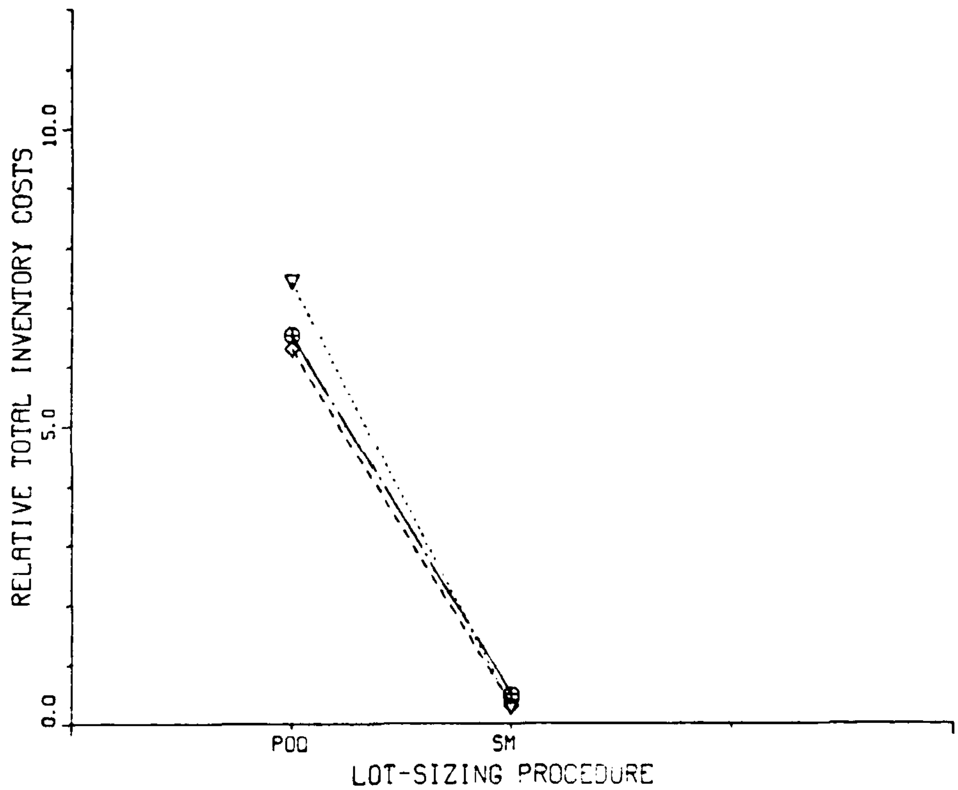

FIGURE 5.8 RELATIVE TOTAL INVENTORY COSTS AS A FUNCTION OF LOT-SIZING PROCEDURE AND GROUPING PATTERN

LEGEND
◇ - TYPE 1 (REGULAR, MINIMUM SEQUENCES)
▽ - TYPE 2 (REGULAR, SCALED SEQUENCES)
⊕ - TYPE 3 (ORIGINAL SEQUENCES)

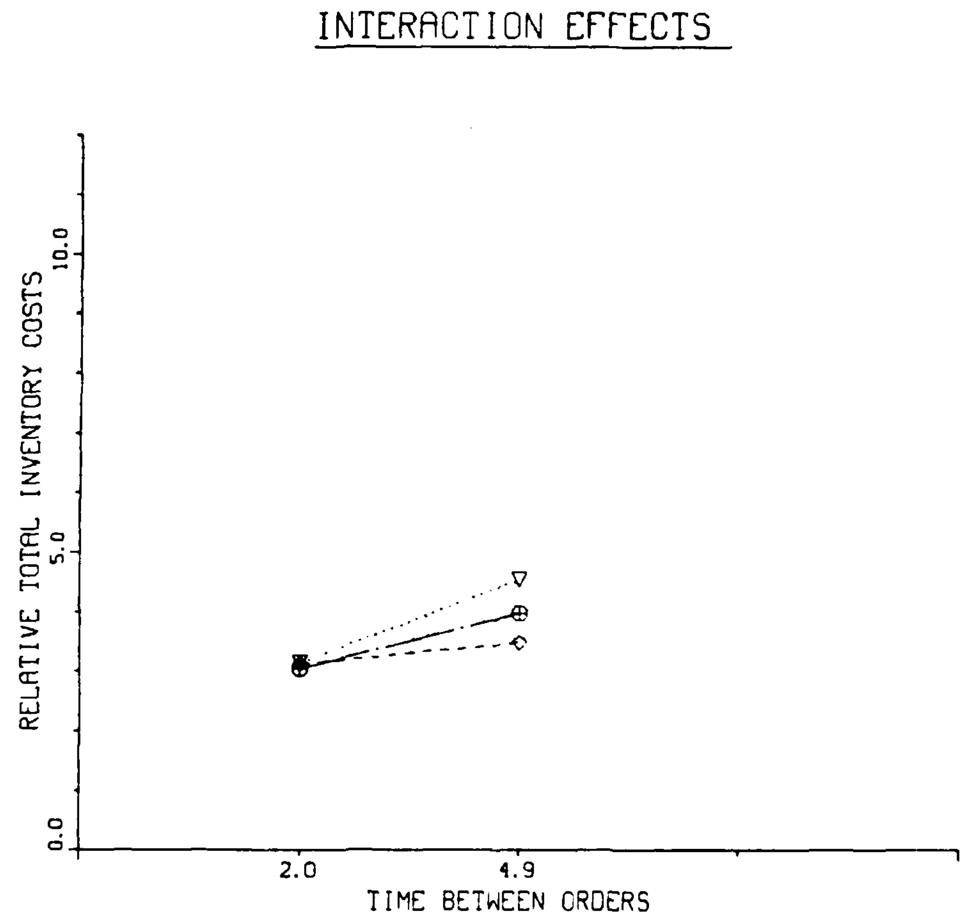

FIGURE 5.9 RELATIVE TOTAL INVENTORY COSTS AS A FUNCTION OF TIME BETWEEN ORDERS AND GROUPING PATTERN

LEGEND

◇ - TYPE 1 (REGULAR, MINIMUM SEQUENCES)
▽ - TYPE 2 (REGULAR, SCALED SEQUENCES)
⊕ - TYPE 3 (ORIGINAL SEQUENCES)

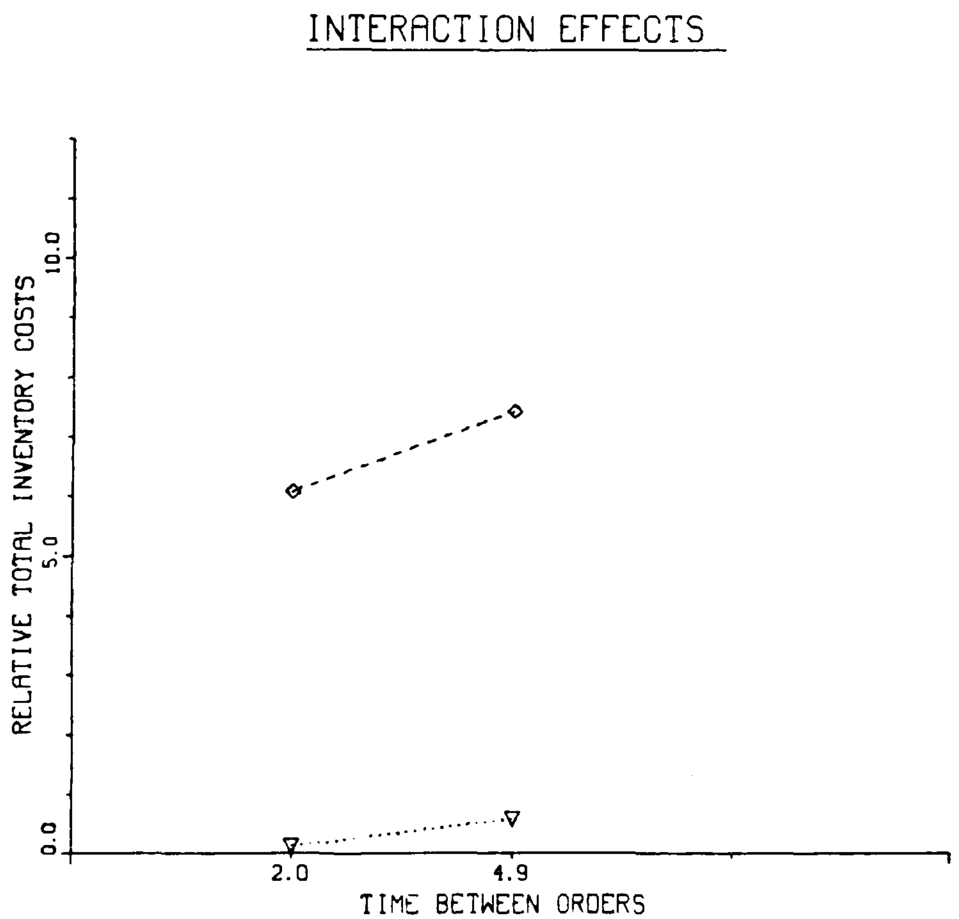

FIGURE 5.10 RELATIVE TOTAL INVENTORY COSTS AS A FUNCTION OF TIME BETWEEN ORDERS AND LOT-SIZING PROCEDURE)

LEGEND
◇ - PERIODIC ORDER QUANTITY
▽ - SILVER-MEAL

Additional Variables

The selection of the best set of independent variables for inclusion in the model is, in large part, a pragmatic, subjective process. There is no one search procedure that can be proven to yield the "best" set of independent variables. The task is to reduce the number of variables to some subset, small enough to facilitate analysis and measurement, yet large enough so that adequate description, control or prediction is possible [66]. In this context we address the question of whether it is worthwhile to include generation procedure and grouping patterns as independent variables.

The criterion used to judge whether it is worthwhile to add generation procedure and grouping pattern as independent variables is the Mean Squared Error (MSE). The addition of independent variables to the ANOVA model can not increase the Sum of Square Error (SSE). The additional variables will, however, decrease the number of degrees of freedom associated with the SSE. Since MSE is the average error per degree of freedom, the reduction in the SSE from the addition of the independent variables may be more than offset by loss of degrees of freedom. By this criterion, the addition of an independent variable is worthwhile if the MSE decreases.

Factor Effects (Source of Error)	F	Level of Significance
Main Effects		
Coefficient of Variation (Cv)	1657.144	.001
Lot-Sizing (LS)	11035.732	.001
Time Between Orders (TBO)	216.543	.001
Interactions		
CV by LS	1250.286	.001
CV by TBO	9.112	.038
LS by TBO	54.395	.001
MSE	2.766	

Table 5.3 --- Three-way Analysis of Variance Results

A three-way ANOVA was run to determine the change in MSE that resulted with the exclusion of the generation procedure and grouping factors from the original model. The results of this run are presented in Table 5.3. The difference in the MSE between the five-way ANOVA and the three-way ANOVA is an increase of 0.58. This increase indicates that the inclusion of generation procedure and grouping pattern as factors is warranted, all else being equal.

Generating Procedure

The most interesting differences found were associated with the Blackburn and Millen requirements generator at a coefficient of variation of .72. This particular combination is unique in that the proportion of null periods is specified independent of the selection of the positive requirement distribution parameters. In contrast both the Wemmerlov and McLaren generation procedures determine null requirements by censoring a continuous distribution. For the Wemmerlov and McLaren procedures, the result is an increased number of small requirements. Table 5.4 provides a comparison of the frequency of occurrence for the three requirements generation procedures for selected requirement intervals.

It is recalled that the requirements vectors, for each generation procedure and frequency interval shown in Table 5.4, have the same average period requirement (100) and coefficient of variation (.72). It is noted that for both the Wemmerlov and McLaren generation procedures approximately 30% of requirements have a value less than 80 units compared to 17% for the Blackburn and Millen procedure. In addition, the coefficient of variation of positive requirements is considerably smaller for the Blackburn and Millen procedure (.45) than for the McLaren (.58) or Wemmerlov (.60) procedures. These differences are not characterized by the coefficient of variation.

Requirement Interval (f)	McLaren	Blackburn & Millen	Wemmerlov
null	12.21	21.00	12.00
0 < f < 40	15.40	4.76	12.38
40 < f < 80	15.38	12.12	17.91
80 < f < 120	15.41	19.68	19.78
120 < f < 160	15.48	20.54	17.04
160 < f < 200	15.38	13.75	11.20
200 < f	10.74	8.15	9.69

Table 5.4 ---- Requirement Interval Frequencies for McLaren, Blackburn & Millen and Wemmerlov Generators for Cv = .72.

Cell Analysis

The effects of the procedure used to generate requirements, and the grouping pattern of those requirements are apparent in a consideration of individual cell responses. As discussed in the preceeding section, the effect of generation procedure on relative total inventory cost is most evident for a coefficient of variation of .72. The effect of grouping is most evident for a coefficient of variation of 1.14. The relative total inventory cost for each combination and level of factors is presented in Table 5.5.

Generation	McLaren	Blackburn & Millen	Wemmerlov	McLaren	Blackburn & Millen	Wemmerlov	McLaren	Blackburn & Millen	Wemmerlov
Grouping					type 1				
Cv		.29			.72			1.14	
POQ - 2.0	1.268	1.288	1.283	8.051	4.166	8.224	9.857	9.218	11.493
- 4.9	4.208	3.766	3.761	7.413	5.306	8.958	9.121	9.412	6.593
SM - 2.0	.019	.171	.165	.064	.102	.290	.228	.078	.231
- 4.9	-.101	.061	.057	.775	.606	.555	.764	.716	.795
Grouping					type 2				
POQ - 2.0	1.268	1.288	1.288	7.720	3.795	7.489	10.905	10.768	11.388
- 4.9	4.208	3.752	3.752	7.906	5.638	9.034	13.266	15.956	14.145
SM - 2.0	.019	.165	.165	.008	.079	.144	.111	.090	.072
- 4.9	-.101	.044	.044	.447	.435	1.092	.538	.781	.739
Grouping					type 3				
POQ - 2.0	1.268	1.254	1.254	8.165	4.008	7.873	9.381	9.622	10.558
- 4.9	4.208	3.774	3.773	8.929	5.655	8.944	7.903	10.460	10.596
SM - 2.0	.019	.153	.153	.099	.118	.193	.235	.213	.255
- 4.9	-.101	.046	.046	1.077	.548	.577	1.405	2.266	1.591

$$\text{POQ - 2.0} = \sum_{i=1}^{10} \frac{\text{POQ Total Inventory Cost} - \text{GR Total Inventory Cost}}{\text{GR Total Inventory Cost}} \times 100$$

for TBO = 2.0

Table 5.5 --- Relative Total Cost, Mean Cell Values

The center section of Table 5.5 illustrates the difference in relative total inventory cost for a coefficient of variation of .72. Of interest, in that section, are the differences in cost based on generation procedure. For the POQ lot-sizing procedure and time between orders of 2.0, the relative total inventory cost for the Blackburn and Millen procedure is approximately one half as large as for either the McLaren or Wemmerlov generators under the same environmental conditions. Similar differences are noted for other cells in that section.

The right section of Table 5.5 highlights the difference in relative total inventory cost resulting from different grouping patterns. Consider a coefficient of variation of 1.14, the Wemmerlov generation procedure, and the POQ lot-sizing procedure. For grouping pattern type 3, an increase in the time between orders results in an <u>increase</u> in relative total inventory cost (10.558 to 10.596). Holding all environmental conditions constant except changing the grouping pattern to type 1, results in a <u>decrease</u> in relative total inventory cost for an increase in time between orders (11.493 to 6.593). Finally, for type 2 grouping pattern, an increase in time between orders results in a <u>increase</u> in relative total inventory cost (11.388 to 14.145). Similar changes in magnitude of results are evident by grouping pattern for other generation and lot-sizing procedures at this coefficient of variation

although only the Wemmerlov procedure has both changes in magnitude and direction.

In Chapter VI we present a summary of the conclusions reached in this research. In addition, the contributions of this study and recommendations for future research are presented.

CHAPTER VI

Conclusion, Contributions and Extensions

The research described in this dissertation is concerned with the adequacy of the coefficient of variation as a descriptor of a requirements vector. The environment in which this question becomes important is in the selection of a lot sizing procedure. In this research we have expanded the characterization of a requirements vector and shown that the procedure used to generate requirements and the grouping pattern of those requirements are statistically significant factors in the analysis of lot sizing procedures. This chapter will present a summary of these results, the contributions of this research, and recommend directions for future research.

Conclusions

This research began with a description of an MRP system and the environment within which the system operates. The general lot-sizing problem and the elements of the system which influence the occurrence of requirements were described. It was determined, in a review of the

literature, that the commonly accepted characterization of lumpiness for a requirements vector was the coefficient of variation. This research demonstrated that the coefficient of variation did not distinguish between requirements vectors with different characteristics. A definition of lumpiness was developed to refine and extend the characterization of requirements vectors used in simulation studies of MRP systems.

A simulation model was developed to determine if additional characteristics, suggested by the new definition of lumpiness, were significant factors when evaluating lot-sizing procedures. Three different dynamic requirements generation procedures were selected from the literature to provide requirements vectors. The vectors generated by these procedures were identical when characterized by the coefficient of variation, yet different when characterized by the new definition.

The response variable used to evaluate the significance of the additional factors was the relative total inventory cost defined as:

$$\text{Reltc} = \left(\frac{\text{TCa} - \text{TCg}}{\text{TCg}} \right) 100$$

where:

Reltc = Relative Total Cost

TCa = Total Inventory Cost for Requirements Vector (i) using:

$$a \begin{Bmatrix} \text{[Periodic Order Quantity Algorithm]} \\ \text{[Silver-Meal Algorithm]} \end{Bmatrix}$$

TCg = Total Inventory Cost for Requirements Vector (i) using Groff Algorithm

A five-factor Analysis of variance was performed in which all five factors (GEN, GP, TBO, LS, Cv) were found to have significant effects on relative total inventory cost. The results of this study indiciate that both the magnitude and direction of change of relative total inventory costs are related to the procedure used to generate a requirements vector and the grouping of requirements within the vector.

The overall perspective of this research has been to address the adequacy of the coefficient of variation as a descriptor of a requirements vector when evaluating lot-sizing procedures. Our findings indicate that while the method used to generate requirements vectors and the grouping patterns of those vectors are significant factors when evaluating lot-sizing procedures, they do not change the conclusions reached using only the coefficient of variation.

Contributions

The research described in this dissertation has addressed the characterization of a requirements vector by the coefficient of variation. We have defined the nature of the problem, and provided a structure for investigation. Contributions have been made in the following areas:

(1) A working definition of the term "lumpiness" has been provided. This definition characterized a requirements vector by identifying those elements which contribute to lumpiness. This definition should serve to standardize the meaning of the term "lumpiness" and more precisely identify those elements of lumpiness which are addressed by future researchers.

(2) A comparison of three dynamic requirements generation procedures was provided in both graphical and statistical format. This comparions illustrated the differences in the requirements vectors which would be considered identical when described by the coefficient of variation and average period requirement.

(3) A taxonomy of the literature related to the generation of requirements vectors has been provided. This taxonomy will assist future researchers in selecting generation procedures.

(4) The effect of the procedure used to generate requirements and the grouping pattern of those requirements within the vector were investigated for common coefficients of variation.

(5) A measure of the grouping periodicity of a requirements vector was provided.

(6) A Simscript II.5 simulation model of the order release mechanism was developed. This model has considerable flexibility and may be used to extend this study to incorporate uncertainity and other commonly used lot-sizing procedures.

Extensions

This dissertation was unable to cover all aspects of the characterization of a requirements vector or address all the questions that need to be asked. Some recommended areas for follow-on study include the following:

(1) This study has considered selected requirements generation procedures. The characterization of a requirements vector and the concept of lumpiness should be investigated using a more general requirements generation procedure. In particular a beta distribution holds considerable potential, as a component of a compound distribution, for incorporating the concept of frequency of requirements and positive reqirement distribution

parameters. The use of a beta distribution would facilitate the approximation of most other continuous distributions.

(2) The elements of lumpiness may be refined into a parameter set that can be readily applied in the field.

(3) The interaction of the elements of lumpiness may be further investigated.

(4) The concept of the grouping of requirements may be extended to include consideration of the magnitude of requirements within groups.

(5) Uncertainty may be introduced into a lumpy requirements vector. Uncertainty may be included as either timing or quantity uncertainty for either requirements or order receipts.

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APPENDICES

APPENDIX A

Computer listing of Simscript II.5 program 'GENE'

Program 'GENE' generates 10 requirements vectors for each of 3 combinations of coefficient of variation (.29, .72, 1.14) and generation procedure (McLaren, Blackburn and Millen, Wemmerlov).

... SOURCE TEXT ...

```
PREAMBLE
DEFINE WW AS A TEXT VARIABLE
DEFINE V AS A 1-DIM ARRAY
DEFINE SAVESEED AS REAL VARIABLE
DEFINE NK AS INTEGER VARIABLE
DEFINE DIST AS A REAL VARIABLE
TALLY MDIST AS THE AVERAGE,NDIST AS THE NUMBER,
  SDIST AS THE STD.DEV OF DIST
DEFINE CIST AS A REAL VARIABLE
TALLY MCIST AS THE AVERAGE,NCIST AS THE NUMBER,
  SCIST AS THE STD.DEV OF CIST
END
```

... SOURCE TEXT ...

```
MAIN
SKIP 2 OUTPUT LINES
LET NK=550
PRINT 2 LINES WITH NK THUS
LET SAVESEED=SEED.V(1)
CALL MCLAREN
LET SEED.V(1)=SAVESEED
CALL BLACKBURN
LET SEED.V(1)=SAVESEED
CALL WEMMERLOV
REWIND UNIT 51
REWIND UNIT 52
END
```

CYBER 74 CACI SIMSCRIPT II.5 VERSION /4.6-00/ NOS-BE 1

IDENT MCLAREN

... SOURCE TEXT ...

```
ROUTINE MCLAREN
DEFINE LOX,HIX AS 1-DIM ARRAYS
RESERVE LOX(*),HIX(*)AS 3
RESERVE V(*)AS 550
LET LOX(1)=49.77052658
LET HIX(1)=150.2294734
LET LOX(2)=-31.613088
LET HIX(2)=227.76
LET LOX(3)=-249.978018
LET HIX(3)=344.94
SKIP 2 OUTPUT LINES
USE UNIT 52 FOR OUTPUT
PRINT 4 LINES THUS
USE UNIT 6 FOR OUTPUT
PRINT 3 LINES THUS
FOR K0=1 TO 3
DO
  LET LOLIMIT=LOX(K0)
  LET HILIMIT=HIX(K0)
  USE UNIT 6 FOR OUTPUT
  PRINT 2 LINES WITH K0,LOLIMIT,HILIMIT THUS
  PRINT 1 LINE THUS
  FOR K1=1 TO 10
  DO
    RESET TOTALS OF CIST,DIST
    FOR K=1 TO NK
    DO
      LET DDIST=UNIFORM.F(LOLIMIT,HILIMIT,1)
      IF DDIST GT 0.0
        LET CIST=DDIST
      ALWAYS
      LET DIST=MAX.F(0.0,DDIST)
      LET HSTV=DIST
      LET V(K)=DIST
    LOOP
    FOR K=1 TO NK,
    WRITE V(K)AS BINARY USING UNIT 51
    USE UNIT 52 FOR OUTPUT
    SKIP 1 OUTPUT LINE
    WRITE K1 AS I 5,/
    WRITE MDIST,SDIST,SDIST/MDIST,
      NDIST AS 4 D(10,4),/
    WRITE MCIST,SCIST,SCIST/MCIST,
      NCIST/NDIST AS 4 D(10,4),/
  LOOP
LOOP
RELEASE V(*),LOX(*),HIX(*)
RETURN
END
```

CYBER 74 CACI SIMSCRIPT II.5 VERSION /4.6-00/ NOS-BE 1

IDENT BLACKBURN

... SOURCE TEXT ...

```
ROUTINE BLACKBURN
DEFINE MUX,SIGX AS 1-DIM ARRAYS
DEFINE PROBO AS VARIABLE
RESERVE MUX(*),SIGX(*)AS 3
RESERVE V(*)AS NK
LET MUX(1)=100.05
LET SIGX(1)=28.95
LET MUX(2)=124.570
LET SIGX(2)=58.850
LET MUX(3)=106.60
LET SIGX(3)=140.40
USE UNIT 52 FOR OUTPUT
PRINT 4 LINES THUS
USE UNIT 6 FOR OUTPUT
PRINT 3 LINES THUS
FOR KO=1 TO 3
DO
  IF KO=1
    LET PROBO=0.0
  ELSE
    LET PROBO=0.2000
  ALWAYS
  LET MU=MUX(KO)
  LET SIG=SIGX(KO)
  USE UNIT 6 FOR OUTPUT
  PRINT 2 LINES WITH KO,MU,SIG THUS
  PRINT 1 LINE THUS
  FOR K1=1 TO 10
  DO
    RESET TOTALS OF CIST,DIST
    FOR K=1 TO NK
    DO
      IF RANDOM.F(2)LE PROBO
        LET DDIST=0.0
      ELSE
        LET DDIST=NORMAL.F(MU,SIG,1)
      ALWAYS
      IF DDIST GT 0.0
        LET CIST=DDIST
      ALWAYS
      LET DIST=MAX.F(0.0,DDIST)
      LET HSTV=DIST
      LET V(K)=DIST
    LOOP
    FOR K=1 TO NK,
    WRITE V(K)AS BINARY USING UNIT 51
    USE UNIT 52 FOR OUTPUT
```

... SOURCE TEXT ...

```
      SKIP 1 OUTPUT LINE
      WRITE K1 AS I 5,/
      WRITE MDIST,SDIST,SDIST/MDIST,
        NDIST AS 4 D(10,4),/
      WRITE MCIST,SCIST,SCIST/MCIST,
        NCIST/NDIST AS 4 D(10,4),/
    LOOP
  LOOP
  RELEASE V(*),MUX(*),SIGX(*)
  RETURN
  END
```

... SOURCE TEXT ...

```
ROUTINE WEMMERLOV
DEFINE MUX,SIGX AS 1-DIM ARRAYS
RESERVE MUX(*),SIGX(*)AS 3
RESERVE V(*)AS NK
LET MUX(1)=100.05
LET SIGX(1)=28.95
LET MUX(2)=95.585
LET SIGX(2)=79.770
LET MUX(3)=62.40
LET SIGX(3)=160.50
USE UNIT 52 FOR OUTPUT
PRINT 4 LINES THUS
USE UNIT 6 FOR OUTPUT
PRINT 3 LINES THUS
FOR K0=1 TO 3
DO
  LET MU=MUX(K0)
  LET SIG=SIGX(K0)
  USE UNIT 6 FOR OUTPUT
  PRINT 2 LINES WITH K0,MU,SIG THUS
  PRINT 1 LINE THUS
  FOR K1=1 TO 10
  DO
    RESET TOTALS OF CIST,DIST
    FOR K=1 TO NK
    DO
      LET DDIST=NORMAL.F(MU,SIG,1)
      IF DDIST GT 0.0
        LET CIST=DDIST
      ALWAYS
      LET DIST=MAX.F(0.0,DDIST)
      LET HSTV=DIST
      LET V(K)=DIST
    LOOP
    FOR K=1 TO NK,
    WRITE V(K)AS BINARY USING UNIT 51
    USE UNIT 52 FOR OUTPUT
    SKIP 1 OUTPUT LINE
    WRITE K1 AS I 5,/
    WRITE MDIST,SDIST,SDIST/MDIST,
      NDIST AS 4 D(10,4),/
    WRITE MCIST,SCIST,SCIST/MCIST,
      NCIST/NDIST AS 4 D(10,4),/
  LOOP
LOOP
RELEASE V(*),MUX(*),SIGX(*)
RETURN
END
```

APPENDIX B

Computer listing of Simscript II.5 program 'ALTER6B'

Program ALTER6B generates 3 requirements vectors from the elements of an input vector. The output vectors have integer valued elements which are the elements of the original vector, rounded to the nearest integer value. Vectors one and two have the sequence length of nulls and positive occurences altered as determined by a scaling factor.

Statistics on each vector are computed.

... SOURCE TEXT ...

```
PREAMBLE
DEFINE Z,V,SSSQ AS 1-DIM REAL ARRAY
DEFINE G AS 1-DIM INTEGER ARRAY
DEFINE WW,NONULL AS TEXT VARIABLE
DEFINE NK,RNK,IPN,IPP,VECTN,PRIOR AS INTEGER VARIABLES
DEFINE FPN,FPP,AVG.NULL,EXP.NULL,EXP.POS
  AS REAL VARIABLES
DEFINE DIST AS A REAL VARIABLE
TALLY MDIST AS THE AVERAGE,MXDIST AS THE MAXIMUM,
  MIDIST AS THE MINIMUM,NDIST AS THE NUMBER,
  SDIST AS THE STD.DEV OF DIST
DEFINE CIST AS A REAL VARIABLE
TALLY MCIST AS THE AVERAGE,NCIST AS THE NUMBER,
  SCIST AS THE STD.DEV OF CIST
DEFINE TT.GO,LAST.POS AS VARIABLES
TALLY KME.GO AS THE CHK MEAN,KSD.GO AS THE CHK STD.DEV,
  KMI.GO AS THE CHK MINIMUM,KMX.GO AS THE CHK MAXIMUM,
  NB.GO AS THE CHK NUMBER,HST.GO(0.0 TO 25.0 BY 1.0)
  AS THE CHK HISTOGRAM OF TT.GO
DEFINE GM.GO AS VARIABLE
TALLY S.GO AS THE SUM,N.GO AS THE NUMBER OF GM.GO
DEFINE TT.G1 AS A VARIABLE
TALLY KME.G1 AS THE CHK MEAN,KSD.G1 AS THE CHK STD.DEV,
  KMI.G1 AS THE CHK MINIMUM,KMX.G1 AS THE CHK MAXIMUM,
  NB.G1 AS THE CHK NUMBER,HST.G1(0.0 TO 25.0 BY 1.0)
  AS THE CHK HISTOGRAM OF TT.G1
DEFINE GM.G1 AS VARIABLE
TALLY S.G1 AS THE SUM,N.G1 AS THE NUMBER OF GM.G1
END
```

CYBER 74 CACI SIMSCRIPT II.5 VERSION /4.6-00/ NOS-BE 1

IDENT MAIN

... SOURCE TEXT ...

```
MAIN
DEFINE ANS AS ALPHA VARIABLE
DEFINE BUNCH AS INTEGER VARIABLE
LET BUNCH=11
LET NONULL="NO NULL PERIODS --- COMPUTATION DISCONTINUED --- "
LET WW="HOW MANY ELEMENTS PER VECTOR ? "
LET NK=550
LET RNK=500
RESERVE V(*),G(*)AS NK
RESERVE SSSQ(*)AS 5
REWIND UNIT 51
REWIND UNIT 31
REWIND UNIT 33
REWIND UNIT 35
REWIND UNIT 37
FOR VECTN=1 TO 90
DO
  FOR K=1 TO NK
  READ V(K)AS BINARY USING UNIT 51
  LET PRIOR=WRITE.V
  USE UNIT 6 FOR OUTPUT
  FOR K=1 TO 14
  WRITE V(K)AS(14)D(6,1)
  USE UNIT PRIOR FOR OUTPUT
  CALL RUNS
  CALL GMIN
  CALL RUN2
  FOR K=1 TO NK
  WRITE G(K)AS(BUNCH)I 4 USING UNIT 31
  CALL INTVAL GIVEN 2.0
  CALL GMIN
  CALL RUN2
  FOR K=1 TO NK
  WRITE G(K)AS(BUNCH)I 4 USING UNIT 33
  LET PRIOR=WRITE.V
  USE UNIT 6 FOR OUTPUT
  FOR K=1 TO 17
  WRITE G(K)AS(17)I 4
  SKIP 1 OUTPUT LINES
```

CYBER 74 CACI SIMSCRIPT II.5 VERSION /4.6-00/ NOS-BE 1

IDENT MAIN

... SOURCE TEXT ...

```
  USE UNIT PRIOR FOR OUTPUT
  FOR K=1 TO NK
  DO
    LET G(K)=INT.F(V(K))
  LOOP
  FOR K=1 TO NK
  WRITE G(K)AS(BUNCH)I 4 USING UNIT 35
  FOR K=1 TO NK
  WRITE V(K)AS(BUNCH)D(9,3)USING UNIT 39
LOOP
RELEASE V(*),G(*)
END
```

CYBER 74 CACI SIMSCRIPT II.5 VERSION /4.6-00/ NOS-BE 1

IDENT GMIN

... SOURCE TEXT ...

```
 ROUTINE GMIN
 DEFINE FLIP,PV,NV,J,CNT,RUNL AS INTEGER VARIABLES
 FOR N=1 TO NK
 DO
   LET G(N)=INT.F(V(N))
 LOOP
 IF(NB.GO LE 0.0)
   GO TO DONE
 ALWAYS
 LET FLIP=1
 LET SNP=NDIST-NCIST
 LET SOC=NB.GO+.001
'AGAIN'
 IF FLIP=1
   LET FLIP=0
   LET RUNL=IPP
   LET RN=RANDOM.F(1)
   IF(RN LE FPP)
     ADD 1 TO RUNL
   ALWAYS
   WHILE(CNT LT RUNL)
   DO
     ADD 1 TO PV
     IF PV>RNK
       GO ENDOFVECTOR
     ALWAYS
     IF V(PV)LE 0.0
       CYCLE
     ELSE
     ADD 1 TO J
     LET G(J)=INT.F(V(PV))
     ADD 1 TO CNT
   LOOP
 ELSE
   LET FLIP=1
   LET RUNL=IPN
```

... SOURCE TEXT ...

```
   IF SNP/SOC GT AVG.NULL
     ADD 1 TO RUNL
   ALWAYS
   SUBTRACT RUNL FROM SNP
   SUBTRACT 1 FROM SOC
   WHILE(CNT LT RUNL)
   DO
     ADD 1 TO PN
     IF PN>RNK
       GO ENDOFVECTOR
     ALWAYS
     IF V(PN)GT 0.0
       CYCLE
     ELSE
     ADD 1 TO J
     LET G(J)=INT.F(V(PN))
     ADD 1 TO CNT
   LOOP
 REGARDLESS
'ENDOFVECTOR'
 IF J LT RNK
   LET CNT=0
   GO AGAIN
 ALWAYS
'DONE'
 RETURN
 END
```

... SOURCE TEXT ...

```
ROUTINE INTVAL GIVEN SCALE
DEFINE SCALE,AVG.POS AS REAL VARIABLES
IF NB.G0>0
  LET AVG.NULL=SCALE*((NDIST-NCIST)/NB.G0)
ELSE
  LET AVG.NULL=0.0
REGARDLESS
LET AVG.POS=SCALE*(NCIST/NB.G1)
LET IPN=TRUNC.F(AVG.NULL)
LET FPN=FRAC.F(AVG.NULL)
LET IPP=TRUNC.F(AVG.POS)
LET FPP=FRAC.F(AVG.POS)
RETURN
END
```

CYBER 74 CACI SIMSCRIPT II.5 VERSION /4.6-00/ NOS-BE 1

IDENT RUNS

... SOURCE TEXT ...

```
ROUTINE RUNS
DEFINE K,POS.PD,LAST.POS,SGN AS INTEGER VARIABLES
RESERVE Z(*)AS 20
RESET TOTALS OF TT.GO,TT.G1,CIST,DIST
RESET TOTALS OF GM.GO,GM.G1
LET POS.PD=0
FOR K=1 TO RNK
DO
  LET DIST=V(K)
  FOR J=1 TO 4
  LET SSSQ(J)=SSSQ(J)+V(K)**(J)
  LET SSSQ(5)=SSSQ(5)+1.0
  IF V(K)LT 0.5
    CYCLE
  ELSE
  LET CIST=V(K)
  IF INT.F(K-LAST.POS)IS EQUAL TO 1
    ADD 1 TO POS.PD
  ELSE
    IF POS.PD>0
      LET TT.G1=POS.PD
      LET GM.G1=LOG.E.F(POS.PD/1.0)
    ALWAYS
    LET TT.GO=K-LAST.POS-1
    LET GM.GO=LOG.E.F(K-LAST.POS-1.0)
    LET POS.PD=1
  REGARDLESS
  LET LAST.POS=K
LOOP
LET WW=" ----------------------------------- "
IF INT.F(K-LAST.POS)IS NOT EQUAL TO 1
  LET TT.GO=K-LAST.POS-1
  LET GM.GO=LOG.E.F(K-LAST.POS-1.0)
ALWAYS
LET TT.G1=POS.PD
LET GM.G1=LOG.E.F(POS.PD/1.0)
CALL SKEWKER YIELDING SK.CV,SK.SK,SK.KT
WRITE VECTN,MXDIST,MIDIST,MXDIST-MIDIST,MDIST,SDIST,
  SDIST/MDIST,SK.SK,SK.KT AS I 8,8 D(8,2),/USING UNIT 37
LET SSSQ(5)=NCIST
CALL SKEWKER YIELDING SK.CV,SK.SK,SK.KT
WRITE NCIST/NDIST,MCIST,SCIST,SCIST/MCIST,SK.SK,
  SK.KT AS B 25,6 D(8,2),/USING UNIT 37
```

... SOURCE TEXT ...

```
 FOR J=1 TO 5
 LET SSSQ(J)=0.0
 IF NB.GO LE 0.0
   LET EXP.NULL=0.0
   LET EXP.POS=9999.9
   FOR J=1 TO 16
   DO
     LET Z(J)=-0.001
   LOOP
   GO TO ALLPOS
 ALWAYS
 LET RFP=NCIST/NDIST
 LET EXP.NULL=(1.0/RFP)-1.0
 LET AVG.NULL=(NDIST-NCIST)/NB.GO
 LET EXP.POS=(1.0/(1.0-RFP))-1.0
 LET EZ=EXP.F(S.G1/N.G1)
 LET FACTOR=KME.G1/EZ
 CALL INTVAL GIVEN 1.0
 LET Z(1)=KMX.G1
 LET Z(2)=KMI.G1
 LET Z(3)=KME.G1
 LET Z(4)=EZ
 LET Z(5)=KSD.G1
 LET Z(6)=KSD.G1/KME.G1
 LET Z(7)=EXP.NULL/KME.G1
 LET Z(8)=EXP.NULL/(KME.G1*FACTOR)
 LET Z(9)=KMX.GO
 LET Z(10)=KMI.GO
 LET Z(11)=KME.GO
 LET Z(12)=-0.001
 LET Z(13)=KSD.GO
 LET Z(14)=KSD.GO/KME.GO
 LET Z(15)=-0.001
 LET Z(16)=NDIST-NCIST
'ALLPOS'
 WRITE EXP.POS,Z(1),Z(2),Z(3),Z(4),Z(5),Z(6),Z(7),
   Z(8)AS 9 D(8,2),/USING UNIT 37
 WRITE EXP.NULL,Z(9),Z(10),Z(11),Z(12),Z(13),Z(14),
   Z(15),Z(16)AS 9 D(8,2),/USING UNIT 37
 RELEASE Z(*)
 RETURN
 END
```

... SOURCE TEXT ...

```
ROUTINE SKEWKER YIELDING SK.CV,SK.SK,SK.KT
LET S1S=SSSQ(1)
LET S2S=SSSQ(2)
LET S3S=SSSQ(3)
LET S4S=SSSQ(4)
LET N=SSSQ(5)
LET M=SSSQ(1)/SSSQ(5)
LET SSQSD=(S2S-(N*M**2.0))/(N-1.0)
LET SSQSD=SQRT.F(SSQSD)
LET SSQSK=(((S3S-(3.0*M*S2S)+(3.0*M**2.0*S1S))/N)-
  M**3.0)/SSQSD**3.0
LET SSQKT=(((S4S-(4.0*M*S3S)+(6.0*M**2.0*S2S)-
  (4.0*M**3.0*S1S))/N)+M**4.0)/SSQSD**4.0
LET SK.CV=SSQSD/M
LET SK.SK=SSQSK
LET SK.KT=SSQKT
RETURN
END
```

CYBER 74 CACI SIMSCRIPT II.5 VERSION /4.6-00/ NOS-BE 1

IDENT RUN2

... SOURCE TEXT ...

```
ROUTINE RUN2
DEFINE K,POS.PD,LAST.POS,SGN AS INTEGER VARIABLES
RESERVE Z(*)AS 20
RESET TOTALS OF TT.GO,TT.G1,CIST,DIST
RESET TOTALS OF GM.GO,GM.G1
LET POS.PD=0
FOR K=1 TO RNK
DO
  LET DIST=G(K)
  IF G(K)LT 0.5
    CYCLE
  ELSE
  LET CIST=G(K)
  IF INT.F(K-LAST.POS)IS EQUAL TO 1
    ADD 1 TO POS.PD
  ELSE
    IF POS.PD>0
      LET TT.G1=POS.PD
      LET GM.G1=LOG.E.F(POS.PD/1.0)
    ALWAYS
    LET TT.GO=K-LAST.POS-1
    LET GM.GO=LOG.E.F(K-LAST.POS-1.0)
    LET POS.PD=1
  REGARDLESS
  LET LAST.POS=K
LOOP
IF INT.F(K-LAST.POS)IS NOT EQUAL TO 1
  LET TT.GO=K-LAST.POS-1
  LET GM.GO=LOG.E.F(K-LAST.POS-1.0)
ALWAYS
LET TT.G1=POS.PD
LET GM.G1=LOG.E.F(POS.PD/1.0)
IF NB.GO LE 0.0
  FOR J=1 TO 16
  DO
    LET Z(J)=-0.001
  LOOP
  GO TO ALLPOS
ALWAYS
LET RFP=NCIST/NDIST
LET EXP.NULL=(1.0/RFP)-1.0
LET AVG.NULL=(NDIST-NCIST)/NB.GO
LET EXP.POS=(1.0/(1.0-RFP))-1.0
```

CYBER 74 CACI SIMSCRIPT II.5 VERSION /4.6-00/ NOS-BE 1

IDENT RUN2

... SOURCE TEXT ...

```
 LET EZ=EXP.F(S.G1/N.G1)
 LET FACTOR=KME.G1/EZ
 LET Z(1)=KMX.G1
 LET Z(2)=KMI.G1
 LET Z(3)=KME.G1
 LET Z(4)=EZ
 LET Z(5)=KSD.G1
 LET Z(6)=KSD.G1/KME.G1
 LET Z(7)=EXP.NULL/KME.G1
 LET Z(8)=EXP.NULL/(KME.G1*FACTOR)
 LET Z(9)=KMX.G0
 LET Z(10)=KMI.G0
 LET Z(11)=KME.G0
 LET Z(12)=-0.001
 LET Z(13)=KSD.G0
 LET Z(14)=KSD.G0/KME.G0
 LET Z(15)=-0.001
 LET Z(16)=NDIST-NCIST
'ALLPOS'
 WRITE EXP.POS,Z(1),Z(2),Z(3),Z(4),Z(5),Z(6),Z(7),
   Z(8)AS 9 D(8,2),/USING UNIT 37
 WRITE EXP.NULL,Z(9),Z(10),Z(11),Z(12),Z(13),Z(14),
   Z(15),Z(16)AS 9 D(8,2),/USING UNIT 37
 RELEASE Z(*)
 RETURN
 END
```

APPENDIX C

Computer listing of Simscript II.5 program 'CUKY2'

Program CUKY2 simulates the operation of the ordering system. For each run of the simulation, a vector of requirements is read from an external file. The ordering, holding and total inventory cost of processing the input vector using each of the selected algorithms is computed and written to a separate file.

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT PRMB.

... SOURCE TEXT ...

```
PREAMBLE
TEMPORARY ENTITIES
  EVERY TPR HAS A X.DMD,A X.RECPT,A X.OHB,
  A X.ORD.REL,A A.DMD,A A.RECPT,A A.OHB,A SHORT,
  A D.PD.DMD,A D.Q.DMD,A D.PD.ORD,A D.Q.ORD,A PD,
  AND BELONGS TO THE SCHED
DEFINE SCHED AS A SET RANKED BY LOW PD
THE SYSTEM OWNS THE SCHED
EVENT NOTICES INCLUDE STOP.SIMULATION,CHECK,RPT,
  COL.DAT,DSTYPD,INITIALIZE
EVERY EXP.DMD HAS A AD..EQ,A AD..QD,AND A AD..PD
EVERY ACT.DMD HAS A AD.EQ,A AD.QD,AND A AD.PD
EVERY EX.OR HAS A OR..EQ,A OR..QD,AND A OR..PD
EVERY ACT.OR HAS A OR.EQ,A OR.QD,AND A OR.PD
DEFINE A.DMD.A,TDMD.A,ZOHB,EX.LD.TIME,
  SFTY.LD.TIME,TOT.LD.TIME,TRIG,TRIGINC,
  AVG.GROSS,AND RYAN AS VARIABLES
DEFINE QUIT,RPT.INTERVAL,TBO,ORD.CST,HLD.CST,
  ECON.PP,MC.TGT,XEOQ,COLDAT.INT,LOVALUE,
  HIVALUE AND COOKIE AS REAL VARIABLES
DEFINE STD,BVTUD,EVTUD,STUD,BVQUD,EVQUD,SQUD,
  BVTUO,EVTUO,STUO,BVQUO,EVQUO,SQUO,LOT.SIZ.ALG,
  RD.VALS,NBR.STREAMS,ISTREAM,POS.PD,PDPC,KIT,AND
  JOSH AS INTEGER VARIABLES
DEFINE CHANGES,PEST,RPARTPD,RWAGW,RL4L,REOQ,GRAPH1,
  PLOT.FQ,PLOTT,STATUS,SKEWKER AS RELEASABLE ROUTINES
PRIORITY ORDER IS INITIALIZE,ACT.OR,ACT.DMD,
  EXP.DMD,EX.OR,CHECK,RPT
DEFINE ACTIVE TO MEAN
DEFINE IDLE TO MEAN
DEFINE ON TO MEAN
DEFINE OFF TO MEAN
DEFINE WAGNER.WHITIN TO MEAN
DEFINE EOQ TO MEAN
DEFINE LOT4LOT TO MEAN
DEFINE PER.ORD.QNT TO MEAN
DEFINE PART.PD.BAL TO MEAN
DEFINE MOM TO MEAN
DEFINE SILVER TO MEAN
DEFINE GROFF TO MEAN
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT PRMB.

... SOURCE TEXT ...

```
DEFINE NAMEALGORITHM AS 1-DIM TEXT ARRAY
DEFINE TT.SUNITS,TT.SOCCUR AS VARIABLES
TALLY NB.SUNITS AS THE SUM OF TT.SUNITS
TALLY NB.SOCCUR AS THE SUM OF TT.SOCCUR
DEFINE ZBO.UNITS AS A VARIAPLE
TALLY SU.Z.UNITS AS THE SUM AND NB.Z.OCCUR AS
  THE NUMBER OF ZBO.UNITS
DEFINE TT.ORDERS,TT.PDS AND TT.POSD AS VARIABLES
TALLY NB.ORD AS THE NUMBER OF TT.ORDERS
TALLY NB.PDS AS THE NUMBER OF TT.PDS
TALLY NB.POSD AS THE NUMBER OF TT.POSD
DEFINE TT.ZOHB AS A VARIABLE
TALLY ME.ZOHB AS THE GND.TOT MEAN,KME.ZOHB AS
   THE CHK MEAN,HD.ZOHB AS
   THE GND.TOT SUM,KHD.ZOHB AS THE CHK SUM,
   SD.ZOHB AS THE GND.TOT STD.DEV,KSD.ZOHB AS
   THE CHK STD.DEV,VD.ZOHB AS THE GND.TOT VARIANCE,
   KVD.ZOHB AS THE CHK VARIANCE,MX.ZOHB AS
   THE GND.TOT MAXIMUM,KMX.ZOHB AS THE CHK
   MAXIMUM OF TT.ZOHB
DEFINE TT.DMD AS A VARIABLE
TALLY ME.DMD AS THE GND.TOT MEAN,KME.DMD AS
  THE CHK MEAN,HD.DMD AS THE GND.TOT SUM,KHD.DMD
  AS THE CHK SUM,SD.DMD AS THE GND.TOT STD.DEV,
  KSD.DMD AS THE CHK STD.DEV,VD.DMD AS THE
  GND.TOT VARIANCE,KVD.DMD AS THE CHK VARIANCE,
  MX.DMD AS THE GND.TOT MAXIMUM,KMX.DMD AS THE
  CHK MAXIMUM OF TT.DMD
TALLY KMI.ZOHB AS THE CHK MINIMUM,MI.ZOHB AS
  THE GND.TOT MINIMUM OF ZOHB
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RMAIN

... SOURCE TEXT ...

```
MAIN
RELEASE CHANGES,PEST,RPARTPD,RWAGW,RL4L,REOQ,
  GRAPH1,PLOT.FQ,PLOTT,STATUS,SKEWKER
DEFINE DUM AS 1-DIM INTEGER ARRAY
DEFINE JK AS INTEGER VARIABLE
DEFINE ITBOA,ITBOB AS SAVED INTEGER VARIABLES
DEFINE WW AS A TEXT VARIABLE
DEFINE SAVESEED AS 1-DIM INTEGER ARRAY
DEFINE SAV.ZOHB AS A SAVED REAL VARIABLE
RESERVE SAVESEED(*)AS 10
RESERVE NAMEALGORITHM(*)AS 8
LET NAMEALGORITHM(1)=" WAGNER WHITEN"
LET NAMEALGORITHM(2)="    EOQ   "
LET NAMEALGORITHM(3)=" LOT 4 LOT"
LET NAMEALGORITHM(4)="PERIODIC ORDER QUANTITY"
LET NAMEALGORITHM(5)="  PART PERIOD   BALANCING "
LET NAMEALGORITHM(6)="MCLAREN ORDER MOMENT   "
LET NAMEALGORITHM(7)="SILVER AND MEAL        "
LET NAMEALGORITHM(8)="  GROFF        "
LET END.RUN=-9.0
FOR M=1 TO 10
LET SAVESEED(M)=SEED.V(M)
USE TAPE 21 FOR INPUT
LET KIT=13
READ JOSH
READ NBR.STREAMS
READ QUIT,RPT.INTERVAL
READ COLDAT.INT
READ RD.VALS
RESERVE DUM(*)AS RD.VALS
READ AVG.GROSS
READ SAV.ZOHB,EX.LD.TIME
LET LOVALUE=1.0
LET HIVALUE=100.0
LET TBO=2.00
FOR ISTREAM=1 TO NBR.STREAMS
DO
  FOR JK=1 TO RD.VALS,
  READ DUM(JK)USING UNIT JOSH
  REWIND KIT
  FOR JK=1 TO RD.VALS,
  WRITE DUM(JK)AS BINARY USING UNIT KIT
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RMAIN

... SOURCE TEXT ...

```
  WRITE ISTREAM,JOSH AS
    "-    -    -    VECTOR",I 4," -    -    - UNIT",I 3
    ,/USING UNIT 11
  FOR LOT.SIZ.ALG=1 TO 8
  DO
    IF LOT.SIZ.ALG=2 OR LOT.SIZ.ALG=3
    OR LOT.SIZ.ALG=1 OR LOT.SIZ.ALG=6 OR LOT.SIZ.ALG=5
      GO TO SKIPOVER
    ALWAYS
    WRITE NAMEALGORITHM(LOT.SIZ.ALG)AS T 15
      USING UNIT 11
    LET ZOHB=SAV.ZOHB
    LET RYAN=0
    LET TOT.LD.TIME=SFTY.LD.TIME+EX.LD.TIME
    SCHEDULE A STOP.SIMULATION AT QUIT
    SCHEDULE A RPT IN 777.0 UNITS
    SCHEDULE A DSTYPD IN 50 UNITS
    SCHEDULE A INITIALIZE NOW
    SCHEDULE A CHECK IN 0.0 UNITS
    SCHEDULE A COL.DAT IN 0.0 UNITS
    START SIMULATION
    LET TIME.V=0.0
    FOR M=1 TO 10
    LET SEED.V(M)=SAVESEED(M)
    RESET TOTALS OF TT.SUNITS,TT.SOCCUR,ZBO.UNITS
    RESET TOTALS OF TT.ORDERS,TT.PDS,TT.POSD
    RESET TOTALS OF TT.ZOHB AND ZOHB
    RESET TOTALS OF TT.DMD
    RESET TOTALS OF ZOHB
   'SKIPOVER'
  LOOP
LOOP
RELEASE SAVESEED(*),DUM(*)
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT REXP.DMD

... SOURCE TEXT ...

```
EVENT EXP.DMD GIVEN AD..EQ,AD..QD AND AD..PD
DEFINE Z,A,B,C AS VARIABLES
DEFINE ZQ AS INTEGER VARIABLE
IF INT.F(AD..PD)LE 0
  GO TO REVISED
  LET Z=TIME.A(L.EV.S(I.EXP.DMD))+1.0
 'TRY.AGAIN'
  LET DDIST=UNIFORM.F(LOVALUE,HIVALUE,STD)
  LET DDIST=MAX.F(0.0,DDIST)
  IF DDIST LE 0.0
    LET Z=Z+1
    GO TRY.AGAIN
  ELSE
  LET ZQ=INT.F(DDIST)
  CREATE A TPR
  LET PD(TPR)=Z
  LET X.DMD(TPR)=ZQ
  LET D.PD.DMD(TPR)=0.0
  LET D.Q.DMD(TPR)=0.0
  FILE THIS TPR IN SCHED
  SCHEDULE AN ACT.DMD GIVEN X.DMD(TPR),
    D.Q.DMD(TPR),AND D.PD.DMD(TPR)
  AT PD(TPR)+D.PD.DMD(TPR)
  LET A=X.DMD(TPR)
  LET B=D.Q.DMD(TPR)
  LET C=D.PD.DMD(TPR)
  GO DOWN
ELSE
LET Z=TIME.V+1
SUBTRACT 1 FROM AD..PD
LET A=AD..EQ
LET B=AD..QD
LET C=AD..PD
FOR EACH TPR IN SCHED
WITH PD(TPR)=TIME.V+1
FIND THE FIRST CASE IF FOUND
  ADD AD..EQ TO X.DMD(TPR)
ELSE
  CREATE A TPR
  LET X.DMD(TPR)=AD..EQ
  LET PD(TPR)=TIME.V+1
  FILE THIS TPR IN SCHED
REGARDLESS
         'DOWN'
SCHEDULE AN EXP.DMD GIVEN A,B,AND C AT Z
         'REVISED'
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RACT.DMD

... SOURCE TEXT ...

```
EVENT ACT.DMD GIVEN AD.EQ,AD.QD AND AD.PD
FOR EACH TPR IN SCHED
WITH PD(TPR)=TIME.V
FIND THE FIRST CASE IF FOUND
  ADD AD.EQ+AD.QD TO A.DMD(TPR)
  IF AD.PD EQ 0
    LET X.DMD(TPR)=X.DMD(TPR)-AD.EQ
  ALWAYS
ELSE
  CREATE A TPR
  LET PD(TPR)=TIME.V
  LET A.DMD(TPR)=AD.EQ+AD.QD
  FILE THIS TPR IN SCHED
REGARDLESS
IF A.DMD(TPR)GT 0.0
  LET RYAN=1
  LET TT.POSD=1.0
  IF INT.F(PD(TPR)-LAST.POS)IS EQUAL TO 1
    ADD 1 TO POS.PD
  ELSE
    LET POS.PD=1
  REGARDLESS
  LET LAST.POS=PD(TPR)
ALWAYS
IF AD.PD LT 0
  FOR EACH TPR IN SCHED
  WITH PD(TPR)=TIME.V-AD.PD
  FIND THE FIRST CASE IF FOUND
    LET X.DMD(TPR)=X.DMD(TPR)-AD.EQ
  ALWAYS
ELSE
REGARDLESS
END
```

AD-A132 480 A SIMULATION STUDY OF THE COEFFICIENT OF VARIATION AS A MEASURE OF VARIAB..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH P B BOBKO 15 APR 83 3/3

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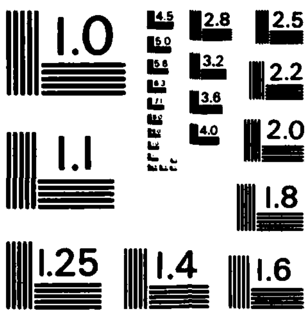

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RINITIALI

... SOURCE TEXT ...

```
EVENT INITIALIZE
DEFINE Y AS 1-DIM INTEGER ARRAY
DEFINE ZQ,NBR.TPRS AS INTEGER VARIABLES
RESERVE Y(*)AS RD.VALS
CALL CERTAIN
CALL RIEOQ
REWIND KIT
LET Z=1.0
LET NBR.TPRS=0
IF RD.VALS LT 1
  GO TO SKIPPER
ALWAYS
WHILE NBR.TPRS IS LESS THAN RD.VALS
DO
  ADD 1.0 TO NBR.TPRS
  READ ZQ AS BINARY USING UNIT KIT
  LET Y(NBR.TPRS)=ZQ
  CREATE A TPR
  LET PD(TPR)=Z
  LET X.DMD(TPR)=ZQ
  LET D.PD.DMD(TPR)=0.0
  LET D.Q.DMD(TPR)=0.0
  FILE THIS TPR IN SCHED
  SCHEDULE AN ACT.DMD GIVEN X.DMD(TPR),D.Q.DMD(TPR),
    AND D.PD.DMD(TPR) AT PD(TPR)+D.PD.DMD(TPR)
  ADD 1 TO Z
LOOP
WRITE ISTREAM AS I 4,/
FOR JK=1 TO 10
DO
  WRITE JK,Y(JK)AS"    Y(",I 2,")",D(5,1)
LOOP
SKIP 1 OUTPUT LINE
RELEASE Y(*)
         'SKIPPER'
WHILE NBR.TPRS IS LESS THAN RD.VALS+1
DO
  LET DDIST=UNIFORM.F(LOVALUE,HIVALUE,STD)
  IF DDIST LE 0.0
    ADD 1.0 TO Z
    CYCLE
  ELSE
  LET DDIST=MAX.F(0.0,DDIST)
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RINITIALI

... SOURCE TEXT ...

```
  LET ZQ=INT.F(DDIST)
  ADD 1 TO NBR.TPRS
  CREATE A TPR
  LET PD(TPR)=Z
  LET X.DMD(TPR)=ZQ
  LET D.PD.DMD(TPR)=0.0
  LET D.Q.DMD(TPR)=0.0
  FILE THIS TPR IN SCHED
  SCHEDULE AN ACT.DMD GIVEN X.DMD(TPR),D.Q.DMD(TPR),
    AND D.PD.DMD(TPR) AT PD(TPR)+D.PD.DMD(TPR)
  SCHEDULE AN EXP.DMD GIVEN X.DMD(TPR),D.Q.DMD(TPR)
    AND D.PD.DMD(TPR)AT Z
  LET Z=TIME.A(L.EV.S(I.EXP.DMD))+1.0
LOOP
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RSTOP.SIM

... SOURCE TEXT ...

```
EVENT STOP.SIMULATION
FOR EACH CHECK IN EV.S(I.CHECK)
DO
  CANCEL THE CHECK
  DESTROY THE CHECK
LOOP
FOR EACH EXP.DMD IN EV.S(I.EXP.DMD)
DO
  CANCEL THE EXP.DMD
  DESTROY THE EXP.DMD
LOOP
FOR EACH RPT IN EV.S(I.RPT)
DO
  CANCEL THE RPT
  DESTROY THE RPT
LOOP
FOR EACH ACT.DMD IN EV.S(I.ACT.DMD)
DO
  CANCEL THE ACT.DMD
  DESTROY THE ACT.DMD
LOOP
FOR EACH EX.OR IN EV.S(I.EX.OR)
DO
  CANCEL THE EX.OR
  DESTROY THE EX.OR
LOOP
FOR EACH COL.DAT IN EV.S(I.COL.DAT)
DO
  CANCEL THE COL.DAT
  DESTROY THE COL.DAT
LOOP
FOR EACH ACT.OR IN EV.S(I.ACT.OR)
DO
  CANCEL THE ACT.OR
  DESTROY THE ACT.OR
LOOP
         'AGAIN'
IF SCHED IS NOT EMPTY
  REMOVE THE LAST TPR FROM SCHED
  DESTROY THIS TPR
  GO AGAIN
ELSE
FOR EACH DSTYPD IN EV.S(I.DSTYPD)
DO
  CANCEL THE DSTYPD
  DESTROY THE DSTYPD
LOOP
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RSTOP.SIM

... SOURCE TEXT ...

```
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RRPT

... SOURCE TEXT ...

```
EVENT RPT
DEFINE AABB AS A SAVED,INTEGER VARIABLE
IF AABB EQ 0
  LET FRPT=TIME.V
  LET LRPT=TIME.V+10
  LET AABB=1
  SCHEDULE A RPT IN 10.0 UNITS
ELSE
  WRITE TIME.V AS" SCHEDULE AT ",I 7,
    " LOOKING BACK 10 PDS ",/
  LET FRPT=TIME.V-10.0
  LET LRPT=TIME.V
  LET AABB=1
  LET RQ=TIME.V+RPT.INTERVAL
  IF(RQ GT QUIT)AND(QUIT-10.0 GT TIME.V)
    LET RQ=QUIT-10.0
  REGARDLESS
  SCHEDULE A RPT AT RQ
ALWAYS
IF TIME.V LT 1.0
  GO TO BINGO
ALWAYS
BEGIN REPORT
PRINTING
FOR EACH TPR IN SCHED
WITH PD(TPR)GE FRPT AND PD(TPR)LE LRPT,
  IN GROUPS OF 11
GO TO TEMP1
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RRPT

... SOURCE TEXT ...

```
PRINT 19 LINES WITH A GROUP OF PD(TPR)FIELDS,
  A GROUP OF X.DMD(TPR)FIELDS,
  A GROUP OF X.RECPT(TPR)FIELDS,
  A GROUP OF X.OHB(TPR)FIELDS,
  A GROUP OF X.ORD.REL(TPR)FIELDS,
  A GROUP OF A.DMD(TPR)FIELDS,
  A GROUP OF A.RECPT(TPR)FIELDS,
  A GROUP OF A.OHB(TPR)FIELDS,
  A GROUP OF SHORT(TPR)FIELDS,
  A GROUP OF D.PD.DMD(TPR)FIELDS,
  A GROUP OF D.Q.DMD(TPR)FIELDS,
  A GROUP OF D.PD.ORD(TPR)FIELDS,AND
  A GROUP OF D.Q.ORD(TPR)FIELDS THUS
         'TEMP1'
PRINT 7 LINES WITH A GROUP OF PD(TPR)FIELDS,
  A GROUP OF A.DMD(TPR)FIELDS,
  A GROUP OF A.RECPT(TPR)FIELDS,
  A GROUP OF A.OHB(TPR)FIELDS THUS
END
WRITE AS" # ",/
         'BINGO'
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RCHECK

... SOURCE TEXT ...

```
EVENT CHECK
DEFINE OLD.ZOHB AS A SAVED REAL VARIABLE
SCHEDULE A CHECK IN 1.0 UNITS
LET TT.PDS=1
IF RYAN EQ 0
  IF OLD.ZOHB GE 0.0
    LET TT.ZOHB=OLD.ZOHB
    LET TT.SUNITS=0.0
  OTHERWISE
    LET TT.ZOHB=0.0
    LET TT.SUNITS=OLD.ZOHB
  REGARDLESS
  LET TT.DMD=0.0
  GO TO NOACTIVITY
ELSE
LET RYAN=0
FOR EACH TPR IN SCHED
WITH PD(TPR)EQ TIME.V
FIND THE FIRST CASE IF FOUND
  GO TINKLE
ELSE
CREATE A TPR
LET PD(TPR)=TIME.V
FILE THIS TPR IN SCHED
         'TINKLE'
LET OLD.OHB=ZOHB
ADD A.RECPT(TPR)TO ZOHB
SUBTRACT A.DMD(TPR)FROM ZOHB
LET TT.DMD=A.DMD(TPR)
IF ZOHB LT 0
  LET A.OHB(TPR)=0
  LET SHORT(TPR)=ZOHB
  LET RYAN=1
  IF OLD.OHB GE 0
    LET ZBO.UNITS=ABS.F(ZOHB)
  ELSE
    IF OLD.OHB>ZOHB
      LET ZBO.UNITS=OLD.OHB-ZOHB
    REGARDLESS
  ALWAYS
ELSE
  LET SHORT(TPR)=0
  LET A.OHB(TPR)=ZOHB
REGARDLESS
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RCHECK

... SOURCE TEXT ...

```
LET MAX.INV=OLD.ZOHB+A.RECPT(TPR)
IF SIGN.F(MAX.INV)EQ SIGN.F(ZOHB)
  LET HX=((MAX.INV+ZOHB)/2.0)*SIGN.F(ZOHB)
  IF HX GT 0
    LET TT.ZOHB=HX
    LET TT.SUNITS=0.0
  ELSE
    LET TT.SUNITS=HX
    LET TT.ZOHB=0.0
  ALWAYS
ELSE
  LET HEIGHT=ABS.F(OLD.ZOHB)+A.RECPT(TPR)
  LET ZPOS=(MAX.INV/2.0)*(MAX.INV/HEIGHT)
  LET ZNEG=(1.0-(MAX.INV/HEIGHT))*ZOHB
  LET TT.ZOHB=ZPOS
  LET TT.SUNITS=ZNEG
ALWAYS
LET OLD.ZOHB=ZOHB
         'NOACTIVITY'
LET TT.SOCCUR=RYAN
CALL ORDERS
IF MOD.F(TIME.V,20)LE 0.00001
  CALL KCHECK
REGARDLESS
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT REX.OR

... SOURCE TEXT ...

```
EVENT EX.OR GIVEN OR..EQ,OR..QD AND OR..PD
IF OR..PD LE 0
  GO PARTY
ELSE
FOR EACH TPR IN SCHED
WITH PD(TPR)EQ TIME.V+1
FIND THE FIRST CASE,IF FOUND,
  ADD OR..EQ TO X.RECPT(TPR)
  GO REESCHED
ELSE
CREATE A TPR
LET PD(TPR)=TIME.V+1
LET X.RECPT(TPR)=OR..EQ
FILE THIS TPR IN SCHED
         'REESCHED'
SCHEDULE A EX.OR GIVEN OR..EQ,OR..QD AND
  OR..PD-1 AT TIME.V+1
         'PARTY'
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RACT.OR

... SOURCE TEXT ...

```
EVENT ACT.OR GIVEN OR.EQ,OR.QD AND OR.PD
LET RYAN=1
FOR EACH TPR IN SCHED
WITH PD(TPR)EQ TIME.V
FIND THE FIRST CASE,IF FOUND,
  ADD OR.EQ+OR.QD TO A.RECPT(TPR)
ELSE
  CREATE A TPR
  LET PD(TPR)=TIME.V
  LET A.RECPT(TPR)=OR.EQ+OR.QD
  FILE THIS TPR IN SCHED
REGARDLESS
IF OR.PD GT 0
  GO TO LATE
ELSE
IF OR.PD EQ 0
  SUBTRACT OR.EQ FROM X.RECPT(TPR)
ELSE
  FOR EACH TPR IN SCHED
  WITH PD(TPR)EQ TIME.V-OR.PD
  FIND THE FIRST CASE,IF FOUND,
    SUBTRACT OR.EQ FROM X.RECPT(TPR)
  ELSE
    PRINT 1 LINE WITH TIME.V-OR.PD THUS
  REGARDLESS
REGARDLESS
         'LATE'
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RRIEOQ

... SOURCE TEXT ...

```
ROUTINE RIEOQ
LET PDPC=52.0
LET HLD.CST=2.00
LET D=SQRT.F(2.0*AVG.GROSS*PDPC)
LET RATIO.SETUP.HOLD=(AVG.GROSS/
  (2.0*PDPC))*TBO**2.0
LET ORD.CST=HLD.CST*RATIO.SETUP.HOLD*PDPC
LET EEOQ=D*SQRT.F(RATIO.SETUP.HOLD)
LET XEOQ=INT.F(EEOQ)
LET ECON.PP=RATIO.SETUP.HOLD*PDPC
IF LOT.SIZ.ALG NE 1
  RETURN
ALWAYS
PRINT 2 LINES WITH AVG.GROSS,ORD.CST,HLD.CST THUS
PRINT 3 LINES WITH RATIO.SETUP.HOLD,TBO,
  EEOQ,XEOQ,ECON.PP THUS
SKIP 2 LINES
IF TBO GT 1.0
  LET QT=TRUNC.F(TBO)
  LET Q1=MOD.F(TBO,QT)
  FOR QI=1 TO(QT-1)
  ADD QI TO QSUM
  LET Q3=Q1+QSUM
  LET MC.TGT=Q3*AVG.GROSS
ELSE
  LET MC.TGT=AVG.GROSS
REGARDLESS
PRINT 1 LINE WITH QT,Q1,QSUM,Q3,MC.TGT THUS
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RCERTAIN

... SOURCE TEXT ...

```
ROUTINE CERTAIN
LET BVTUD=0
LET EVTUD=0
LET BVQUD=0
LET EVQUD=0
LET BVTUO=0
LET EVTUO=0
LET BVQUO=0
LET EVQUO=0
LET TRIG=0
LET SFTY.LD.TIME=0
LET STD=1
LET STUD=2
LET SQUD=4
LET STUO=5
LET SQUO=6
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RORDERS

... SOURCE TEXT ...

```
ROUTINE FOR ORDERS
LET EOHB=ZOHB
FOR EACH TPR IN SCHED
WITH PD(TPR)GT TIME.V AND PD(TPR)LE
TIME.V+TOT.LD.TIME
DO THE FOLLOWING
  ADD X.RECPT(TPR)TO EOHB
  SUBTRACT X.DMD(TPR)FROM EOHB
  LET X.OHB(TPR)=EOHB
LOOP
IF INT.F(EOHB)LT 0
  GO PLACE.ORDER
ELSE
IF EOHB GE TRIG
  GO TO NO.ORDER
ELSE
         'PLACE.ORDER'
GO TO'LWAGNER'OR'LEOQ'OR'LLOT4LOT'OR
  'LPER.ORD.QNT'OR'LPART.PD.BAL'OR'
  LMOM'OR'LSILVER'OR'LGROFF'PER LOT.SIZ.ALG
'LEOQ'
 CALL REOQ GIVEN EOHB YIELDING AMTTORD
 GO SWING
'LLOT4LOT'
 CALL RL4L GIVEN EOHB YIELDING AMTTORD
 GO SWING
'LPER.ORD.QNT'
 CALL RPERORD YIELDING AMTTORD
 GO SWING
'LPART.PD.BAL'
 CALL RPARTPD YIELDING AMTTORD
 GO SWING
'LWAGNER'
 CALL RWAGW YIELDING AMTTORD
 GO SWING
'LMOM'
 CALL RMOM YIELDING AMTTORD
 GO SWING
'LSILVER'
 CALL RSILVER YIELDING AMTTORD
 GO SWING
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RORDERS

... SOURCE TEXT ...

```
'LGROFF'
 CALL RGROFF YIELDING AMTTORD
'SWING'
 IF AMTTORD LE 0.001
   GO NO.ORDER
 ELSE
 FOR EACH TPR IN SCHED
 WITH PD(TPR)EQ TIME.V
 FIND THE FIRST CASE,IF FOUND,
   LET X.ORD.REL(TPR)=AMTTORD
 ELSE
   CREATE A TPR
   LET PD(TPR)=TIME.V
   LET X.ORD.REL(TPR)=AMTTORD
   FILE THIS TPR IN SCHED
 REGARDLESS
 LET TT.ORDERS=1
 FOR EACH TPR IN SCHED
 WITH PD(TPR)EQ TIME.V+EX.LD.TIME
 FIND THE FIRST CASE,IF FOUND,
   ADD AMTTORD TO X.RECPT(TPR)
   LET D.PD.ORD(TPR)=0
   LET D.Q.ORD(TPR)=0
 ELSE
   CREATE A TPR
   LET X.RECPT(TPR)=AMTTORD
   LET D.PD.ORD(TPR)=0
   LET D.Q.ORD(TPR)=0
   LET PD(TPR)=TIME.V+EX.LD.TIME
   FILE THIS TPR IN SCHED
 REGARDLESS
 SCHEDULE A EX.OR GIVEN AMTTORD,D.Q.ORD(TPR)
   AND D.PD.ORD(TPR)AT TIME.V+EX.LD.TIME
 SCHEDULE A ACT.OR GIVEN AMTTORD,D.Q.ORD(TPR)
   AND D.PD.ORD(TPR)AT TIME.V+EX.LD.TIME+D.PD.ORD(TPR)
'NO.ORDER'
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RREOQ

... SOURCE TEXT ...

```
ROUTINE REOQ GIVEN EOHB YIELDING AMTTORD
IF EOHB*(-1.0)+TRIG GT XEOQ
  LET AMTTORD=EOHB*(-1.0)+TRIG
ELSE
  LET AMTTORD=XEOQ
REGARDLESS
RETURN
END
```

```
SIMSCRIPT II.5 VERSION /4.5-00/   NOS-BE   1

                                                        IDENT   RRL4L

   ... SOURCE TEXT ...
       ---------------


ROUTINE RL4L GIVEN EOHB YIELDING AMTTORD
LET AMTTORD=EOHB*(-1.0)+TRIG
RETURN
END
```

```
SIMSCRIPT II.5 VERSION /4.5-00/   NOS-BE   1

                                                        IDENT   RRMOM

   ... SOURCE TEXT ...
       ---------------


ROUTINE RMOM YIELDING AMTTORD
LET RO=TIME.V+1.0
LET R1=TIME.V
LET CPP=0.0
LET AMTTORD=0.0
         'L1'
FOR EACH TPR IN SCHED
WITH PD(TPR)GT R1 AND X.DMD(TPR)GT 0
FIND THE FIRST CASE IF FOUND
  LET NPC=PD(TPR)-RO
  LET CAND=NPC*X.DMD(TPR)
  LET DELTB=MC.TGT-(CPP+CAND)
  IF DELTB GT 0.0
    ADD X.DMD(TPR)TO AMTTORD
    ADD CAND TO CPP
    LET R1=PD(TPR)
    GO TO L1
  ELSE
  IF CAND LE(ORD.CST/HLD.CST)
    ADD X.DMD(TPR)TO AMTTORD
  ALWAYS
ELSE
  PRINT 1 LINE THUS
ALWAYS
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RRSILVER

... SOURCE TEXT ...

```
ROUTINE RSILVER YIELDING AMTTORD
LET R1=TIME.V
LET TT=1
FOR EACH TPR IN SCHED
WITH PD(TPR)GE R1 AND X.DMD(TPR)GT 0
FIND THE FIRST CASE IF FOUND
  LET CPP=ECON.PP
  LET AMTTORD=X.DMD(TPR)
  LET R1=PD(TPR)
ELSE
  LET AMTTORD=0.0
  PRINT 1 LINE THUS
  RETURN
REGARDLESS
WHILE TT LT 50
DO
  ADD 1 TO R1
  FOR EACH TPR IN SCHED
  WITH PD(TPR)EQ R1 AND X.DMD(TPR)GT 0
  FIND THE FIRST CASE IF FOUND
    IF((TT**2.0)*X.DMD(TPR))GT CPP
      GO TO TONTO
    ALWAYS
    ADD 1 TO TT
    ADD X.DMD(TPR)TO AMTTORD
    ADD((TT-1)*X.DMD(TPR))TO CPP
  ELSE
    ADD 1 TO TT
  ALWAYS
LOOP
         'TONTO'
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RRGROFF

... SOURCE TEXT ...

```
ROUTINE RGROFF YIELDING AMTTORD
LET R1=TIME.V
LET TT=1
FOR EACH TPR IN SCHED
WITH PD(TPR)GE R1 AND X.DMD(TPR)GT 0
FIND THE FIRST CASE IF FOUND
  LET AMTTORD=X.DMD(TPR)
  LET R1=PD(TPR)
ELSE
  LET AMTTORD=0.0
  PRINT 1 LINE THUS
  RETURN
REGARDLESS
WHILE TT LT 50
DO
  ADD 1 TO R1
  FOR EACH TPR IN SCHED
  WITH PD(TPR)EQ R1 AND X.DMD(TPR)GT 0
  FIND THE FIRST CASE IF FOUND
    IF(TT*(TT+1)*X.DMD(TPR))GE(2*ECON.PP)
      GO TO TONTO
    ALWAYS
    ADD 1 TO TT
    ADD X.DMD(TPR)TO AMTTORD
  ELSE
    ADD 1 TO TT
  ALWAYS
LOOP
         'TONTO'
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RRPERORD

... SOURCE TEXT ...

```
ROUTINE FOR RPERORD YIELDING AMTTORD
LET TPERORD=TRUNC.F(TBO)
LET EOHB=ZOHB
FOR EACH TPR IN SCHED
WITH PD(TPR)GT TIME.V AND PD(TPR)LE TIME.V+TPERORD
DO THE FOLLOWING
  ADD X.RECPT(TPR)TO EOHB
  SUBTRACT X.DMD(TPR)FROM EOHB
LOOP
LET AMTTORD=EOHB*(-1.0)
IF AMTTORD LE .001
  GO TO QUITER
ELSE
         'QUITER'
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RRPARTPD

... SOURCE TEXT ...

```
ROUTINE FOR RPARTPD YIELDING AMTTORD
LET RO=TIME.V+1.0
LET R1=TIME.V
LET CPP=0.0
LET DELTA=ECON.PP
LET AMTTORD=0.0
          'L1'
FOR EACH TPR IN SCHED
WITH PD(TPR)GT R1 AND X.DMD(TPR)GT O
FIND THE FIRST CASE IF FOUND
  LET NPC=PD(TPR)-RO
  LET CAND=NPC*X.DMD(TPR)
  LET DELTB=ECON.PP-(CPP+CAND)
  IF DELTB GT 0.0
    LET DELTA=DELTB
    ADD X.DMD(TPR)TO AMTTORD
    ADD CAND TO CPP
    LET R1=PD(TPR)
    GO TO L1
  ELSE
  IF ABS.F(DELTB)LT DELTA
    ADD X.DMD(TPR)TO AMTTORD
  ALWAYS
ELSE
  PRINT 1 LINE THUS
ALWAYS
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RRWAGW

... SOURCE TEXT ...

```
ROUTINE RWAGW YIELDING AMTTORD
DEFINE FN AS A 2-DIM REAL ARRAY
DEFINE MM AS A 1-DIM REAL ARRAY
DEFINE HTPR,TPRZ,EARLYZ,EARLY,NTPRZ,ZPD,ZPI AND
  CPI AS INTEGER VARIABLES
RESERVE FN(*,*)AS 50 BY 5
RESERVE MM(*)AS 5
LET FN(1,1)=INT.F(TIME.V)
LET FN(1,5)=0.0
LET FN(1,2)=0.0
LET FN(1,3)=0.0
LET FN(1,4)=0.0
FOR EACH TPR IN THE SCHED
WITH PD(TPR)GT TIME.V AND X.DMD(TPR)GT 0
FIND EARLYZ=TPR IF FOUND
  LET EARLIEST=PD(EARLYZ)
  LET FN(2,1)=PD(TPR)
  LET FN(2,2)=ORD.CST
  LET FN(2,4)=PD(TPR)
  LET FN(2,3)=PD(TPR)
  LET FN(2,5)=X.DMD(TPR)
  LET CP=PD(TPR)
  LET ZPD=FN(2,1)-1.0
  LET CPI=2
 'OVER'
  ADD 1 TO CPI
  ADD 1 TO CP
  IF CPI>19
    GO TO HORIZON
  ELSE
  FOR EACH TPR IN SCHED
  WITH PD(TPR)=CP AND X.DMD(TPR)>0
  FIND HTPR=TPR IF FOUND
    LET MMIN=RINF.C
    FOR PDX=EARLIEST TO CP-1
    DO
      FOR EACH TPR FROM EARLYZ IN SCHED
      WITH PD(TPR)=PDX AND X.DMD(TPR)GT 0
      FIND TPRZ=TPR IF FOUND
        LET COST=ORD.CST
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RRWAGW

... SOURCE TEXT ...

```
        LET AMTT=X.DMD(TPR)
        LET ZPI=PD(TPR)-ZPD
        LET DELTZ=PD(TPR)
       'LBL2'
        LET NTPRZ=S.SCHED(TPRZ)
        IF NTPRZ LE 0
          GO TO LBL3
        ELSE
        IF PD(NTPRZ)GT CP
          GO TO LBL3
        ELSE
        IF X.DMD(NTPRZ)GT 0
          LET DELTPD=PD(NTPRZ)-DELTZ
          ADD X.DMD(NTPRZ)TO AMTT
          ADD(X.DMD(NTPRZ)*DELTPD*HLD.CST)TO COST
        ALWAYS
        LET TPRZ=NTPRZ
        GO TO LBL2
      ELSE
      CYCLE
     'LBL3'
      ADD FN(ZPI,2)TO COST
      IF COST LE MMIN
        LET MMIN=COST
        LET MM(2)=COST
        LET MM(3)=PD(TPR)
        LET MM(4)=CP
        LET MM(5)=AMTT
        IF PD(TPR)GT EARLIEST
          LET EARLYZ=TPR
          LET EARLIEST=PD(TPR)
        ALWAYS
      ALWAYS
    LOOP
    LET COST=ORD.CST+FN(CPI-1,2)
    IF COST LE MMIN
      GO TO HORIZON
    ELSE
    LET FN(CPI,1)=CP
    FOR KM=2 TO 5
    LET FN(CPI,KM)=MM(KM)
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RRWAGW

... SOURCE TEXT ...

```
    GO TO OVER
  ELSE
  LET FN(CPI,1)=CP
  FOR KM=2 TO 5
  LET FN(CPI,KM)=FN(CPI-1,KM)
  GO TO OVER
ELSE
WRITE CP AS" >>>>> CURRENT PERIOD ",I 2,
  " HAS NO DEMAND ",/
LET FN(CPI,1)=CP
FOR KM=2 TO 5
LET FN(CPI,KM)=FN(CPI-1,KM)
         'HORIZON'
SUBTRACT 1 FROM CPI
WHILE FN(CPI,3)GT FN(2,1)
DO
  LET ZPI=FN(CPI,3)
  WHILE FN(CPI,1)GE ZPI
  DO
    SUBTRACT 1 FROM CPI
  LOOP
LOOP
LET AMTTORD=FN(CPI,5)
RELEASE FN(*,*)
RELEASE MM(*)
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RSTATUS

... SOURCE TEXT ...

```
ROUTINE STATUS
WRITE NAMEALGORITHM(LOT.SIZ.ALG)AS/,
  "------------- ",T*," ------------------------ ",/
PRINT 3 LINES WITH NB.PDS,NB.ORD,NB.POSD THUS
PRINT 1 LINE THUS
PRINT 6 LINES WITH ME.ZOHB,VD.ZOHB,
  SD.ZOHB,MX.ZOHB,MI.ZOHB THUS
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RDSTYPD

... SOURCE TEXT ...

```
EVENT DSTYPD
SCHEDULE A DSTYPD IN 50 UNITS
LET DEST.TIME=TIME.V-12.0
         'AGAIN'
REMOVE FIRST TPR FROM SCHED
IF PD(TPR)LT DEST.TIME
  DESTROY THIS TPR
  GO AGAIN
ELSE
FILE THIS TPR IN SCHED
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RKCHECK

... SOURCE TEXT ...

```
ROUTINE KCHECK
IF TIME.V LT 1.0
  RETURN
ELSE
RESET CHK TOTALS OF TT.ZOHB AND ZOHB
RESET CHK TOTALS OF TT.DMD
RESET CHK TOTALS OF ZOHB
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RGRAPH1

... SOURCE TEXT ...

```
ROUTINE GRAPH1
DEFINE IX AS A INTEGER VARIABLE
FOR I=20 TO 70 BY 5
DO
  LET IX=TRUNC.F((I-10)/10.0)
  WRITE IX AS B I,I 1
LOOP
SKIP 1 OUTPUT LINE
FOR I=15 TO 70 BY 5
DO
  LET IX=MOD.F((I-10),10.0)
  WRITE IX AS B I,I 1
LOOP
SKIP 1 OUTPUT LINE
FOR I=11 TO 66 BY 5
WRITE AS B I,"----+"
SKIP 1 OUTPUT LINE
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RPLOT.FQ

... SOURCE TEXT ...

```
ROUTINE PLOT.FQ GIVEN HH.XX,HHNBR,KSYMB
DEFINE HH.XX AS A 1-DIM ARRAY
DEFINE M,KSYMB AS INTEGER VARIABLES
DEFINE SYMB AS A 1-DIM ALPHA ARRAY
RESERVE SYMB(*)AS 3
LET SYMB(1)="*"
LET SYMB(2)="#"
LET SYMB(3)="@"
LET HSTR1=0
LET HSTR2=25
LET HSTR3=1
SKIP 2 OUTPUT LINES
CALL GRAPH1
WRITE HSTR1 AS B 3,I 3,B 10,"1"
FOR M=1 TO((HSTR2-HSTR1)/HSTR3)+1
DO
  LET HB=(HH.XX(M)*100.0/HHNBR)+10
  IF HB GT 70
    LET HB=71
  ALWAYS
  WRITE AS B 70," "
  WRITE SYMB(KSYMB)AS B 10,"1",B HB,A 1,/
  WRITE HSTR1+(HSTR3*(M)AS B 3,I 3,B 10,"1"
LOOP
SKIP 2 OUTPUT LINES
RELEASE SYMB
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RPLOTT

... SOURCE TEXT ...

```
ROUTINE PLOTT
DEFINE ALGNAME AS A TEXT VARIABLE
LET READ.UNIT=READ.V
LET READ.V=41
         'LBL1'
SKIP 1 INPUT CARD
SKIP 1 OUTPUT CARD
READ ALGNAME AS T 30
WRITE ALGNAME AS B 10,"----",T 30,"----",/
SKIP 2 OUTPUT LINES
CALL GRAPH1
         'LBL2'
IF DATA IS ENDED
  GO TO ENDALL
ELSE
SKIP 1 INPUT LINE
WRITE AS B 10,"1",/
READ TV AS D(10,1)
IF TV GT O
  WRITE TV AS B 2,I 5,B 10,"1"
  READ KMZ,KVD,MZ,VD AS 4 D(10,2)
  WRITE AS B KMZ/50.0+10,"*"
  WRITE AS B MZ/50.0+10,"+"
  SKIP 1 OUTPUT LINE
  GO TO LBL2
ELSE
GO TO LBL1
         'ENDALL'
SKIP 2 OUTPUT LINES
WRITE AS" OUTPUT FINISHED ",/
LET READ.V=READ.UNIT
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RCOL.DAT

... SOURCE TEXT ...

```
EVENT COL.DAT
DEFINE CDAT99 AS A SAVED INTEGER VARIABLE
DEFINE CRELEASE AS A SAVED INTEGER VARIABLE
DEFINE BEGIN.TIME AS A SAVED REAL VARIABLE
DEFINE HZ.FQ AS A 1-DIM ARRAY
DEFINE M AS AN INTEGER VARIABLE
RESERVE HZ.FQ(*)AS 26
IF CDAT99 EQ 0
  LET BEGIN.TIME=TIME.V+1.0
  LET LAST.POS=TIME.V
  LET POS.PD=0
  RESET TOTALS OF TT.SUNITS,TT.SOCCUR,ZBO.UNITS
  RESET TOTALS OF TT.ORDERS,TT.PDS,TT.POSD
  RESET TOTALS OF TT.ZOHB AND ZOHB
  RESET TOTALS OF TT.DMD
  FOR EACH TPR IN SCHED
  WITH PD(TPR)EQ TIME.V AND X.ORD.REL(TPR)GT 0
  FIND THE FIRST CASE,IF FOUND,
    LET CRELEASE=1
  ELSE
    LET CRELEASE=-2
  REGARDLESS
  LET CDAT99=1
  SCHEDULE A COL.DAT IN TIME.V+COLDAT.INT UNITS
ELSE
  FOR EACH TPR IN SCHED
  WITH PD(TPR)EQ TIME.V AND X.ORD.REL(TPR)GT 0
  FIND THE FIRST CASE,IF FOUND,
    SUBTRACT 1 FROM CRELEASE
  ELSE
    ADD 1 TO CRELEASE
  REGARDLESS
  IF CRELEASE GT 1
    LET TT.ORDERS=1
  ALWAYS
  LET CDAT99=0
  LET HOLD.COST=HD.ZOHB*HLD.CST
  LET SETUP.COST=(NB.ORD)*ORD.CST
  LET TOT.COST=HOLD.COST+SETUP.COST
  CALL WRITE11 GIVEN SETUP.COST,HOLD.COST,TOT.COST
  RELEASE HZ.FQ(*)
ALWAYS
END
```

```
SIMSCRIPT II.5 VERSION /4.5-00/  NOS-BE  1

                                             IDENT   RWRITE11

   ... SOURCE TEXT ...
       ---------------


ROUTINE WRITE11 GIVEN SETUP.COST,HOLD.COST,TOT.COST
WRITE SETUP.COST,HOLD.COST,TOT.COST AS
  B 20,3 D(10,2),/USING UNIT 11
RETURN
END


SIMSCRIPT II.5 VERSION /4.5-00/  NOS-BE  1

                                             IDENT   RSKEWKER

   ... SOURCE TEXT ...
       ---------------


ROUTINE SKEWKER YIELDING SK.CV,SK.SK,SK.KT
LET S1S=SSSQ(1)
LET S2S=SSSQ(2)
LET S3S=SSSQ(3)
LET S4S=SSSQ(4)
LET N=SSSQ(5)
LET M=SSSQ(1)/SSSQ(5)
LET SSQSD=(S2S-(N*M**2.0))/(N-1.0)
LET SSQSD=SQRT.F(SSQSD)
LET SSQSK=(((S3S-(3.0*M*S2S)+(3.0*M**2.0*S1S))/N)
  -M**3.0)/SSQSD**3.0
LET SSQKT=(((S4S-(4.0*M*S3S)+(6.0*M**2.0*S2S)
  -(4.0*M**3.0*S1S))/N)+M**4.0)/SSQSD**4.0
LET SK.CV=SSQSD/M
LET SK.SK=SSQSK
LET SK.KT=SSQKT
PRINT 3 LINES WITH SSQSD,SSQSK,SSQKT,N,M THUS
CALL PEST GIVEN M,SSQSD,SK.SK,SK.KT
RETURN
END
```

SIMSCRIPT II.5 VERSION /4.5-00/ NOS-BE 1

IDENT RPEST

... SOURCE TEXT ...

```
ROUTINE PEST GIVEN MEAN,SIG,B1,B2
DEFINE MEAN,SIG,B1,B2 AS REAL VARIABLES
DEFINE HILIMIT,LOLIMIT,RANGE AS REAL VARIABLES
LET R=(6*(B2-B1-1))/(3*B1-2*B2+6)
LET RR=ABS.F(R)
LET E=(RR**2.0)/(4.0+((0.25*B1*((R+2.0)**2.0)))/(R+1.0))
LET Z=SQRT.F(RR**2-4*E)
LET RT1=(R+Z)/2.0
LET RT2=(R-Z)/2.0
PRINT 2 LINES WITH R,E,Z,RT1,RT2 THUS
IF(RT1 LE 0.0)OR(RT2 LE 0.0)
  LET PXX=9.9
  LET QXX=9.9
  LET LOLIMIT=0.00001
  LET HILIMIT=0.00001
  LET RANGE=0.00001
  PRINT 3 LINES THUS
  RETURN
ALWAYS
IF RT1 GE RT2
  LET LARGE=RT1
  LET SMALL=RT2
ELSE
  LET LARGE=RT2
  LET SMALL=RT1
ALWAYS
IF B1 GT 0
  LET PXX=SMALL
  LET QXX=LARGE
ELSE
  LET PXX=LARGE
  LET QXX=SMALL
ALWAYS
LET BB=SIG*R*(SQRT.F((R+1.0)/E))
LET LOLIMIT=MEAN-((BB*PXX)/(PXX+QXX))
LET HILIMIT=MEAN+((BB*PXX)/(PXX+QXX))
LET RANGE=HILIMIT-LOLIMIT
PRINT 5 LINES WITH PXX,QXX,LOLIMIT,HILIMIT,RANGE THUS
RETURN
END
```

APPENDIX D

Summary Statistics for Each Requirements Vector used in the simulation.

The indirect statistical measures of each requirements vector remain unchanged as the pattern of null and positive sequences is altered. The measures presented, include all periods in the computation of standard deviation and coefficient of variation. The 'generator' column indicates the generation technique and coefficient of variation used with the procedure. 'M29' indicates McLaren, coefficient of variation of .29.

INDIRECT PARAMETERS OF GENERATED REQUIREMENTS VECTORS

GENERATOR	VECTOR NBR	MAX	MIN	MEAN	STD DEV	COEFF OF VAR	FREQ OF OCCUR
MCLAREN (CV=.29)							
	1.00	150.	50.0	99.3	28.64	.29	1.00
	2.00	150.	50.1	98.7	28.76	.29	1.00
	3.00	150.	50.1	100.	28.89	.29	1.00
	4.00	150.	49.9	99.1	28.38	.29	1.00
	5.00	150.	51.0	99.9	28.63	.29	1.00
	6.00	150.	49.9	100.	28.77	.29	1.00
	7.00	150.	49.9	99.0	28.45	.29	1.00
	8.00	150.	49.9	100.	29.14	.29	1.00
	9.00	150.	50.0	101.	29.27	.29	1.00
	10.00	150.	50.0	99.1	27.67	.28	1.00
MIN		150.	49.9	98.7	27.67	.28	1.00
MAX		150.	51.0	101.	29.27	.29	1.00
MEAN		150.	50.1	99.8	28.660	.2890	1.0000
MCLAREN (CV=.72)							
	11.00	227.	0	104.	69.93	.67	.90
	12.00	228.	0	98.2	71.96	.73	.88
	13.00	227.	0	104.	73.38	.71	.88
	14.00	227.	0	96.8	72.15	.75	.89
	15.00	226.	0	96.0	73.99	.77	.85
	16.00	227.	0	103.	73.02	.71	.87
	17.00	227.	0	95.0	71.62	.75	.86
	18.00	227.	0	101.	71.27	.71	.87
	19.00	227.	0	99.8	70.49	.71	.90
	20.00	227.	0	98.6	70.92	.72	.88
MIN		226.	0	95.0	69.93	.67	.85
MAX		228.	0	104.	73.99	.77	.90
MEAN		227.	0	99.5	71.873	.7230	.8780

INDIRECT PARAMETERS OF GENERATED REQUIREMENTS VECTORS

GENERATOR	VECTOR NBR	MAX	MIN	MEAN	STD DEV	COEFF OF VAR	FREQ OF OCCUR
MCLAREN (CV=1.14)							
	21.00	344.	0	97.8	114.38	1.17	.58
	22.00	344.	0	99.3	112.03	1.13	.60
	23.00	345.	0	105.	117.35	1.11	.61
	24.00	344.	0	108.	114.12	1.06	.63
	25.00	342.	0	98.0	112.12	1.14	.58
	26.00	343.	0	105.	114.80	1.09	.59
	27.00	344.	0	101.	114.71	1.13	.59
	28.00	344.	0	98.6	108.80	1.10	.62
	29.00	344.	0	91.4	110.73	1.21	.54
	30.00	344.	0	106.	114.13	1.08	.61
MIN		342.	0	91.4	108.80	1.06	.54
MAX		345.	0	108.	117.35	1.21	.63
MEAN		344.	0	101.	113.32	1.1220	.5950
BLACKBURN & MILLEN (CV=.29)							
	31.00	193.	5.67	98.7	28.74	.29	1.00
	32.00	184.	5.53	101.	28.53	.28	1.00
	33.00	197.	16.9	102.	29.29	.29	1.00
	34.00	201.	28.8	99.4	27.32	.27	1.00
	35.00	189.	0	99.5	30.57	.31	1.00
	36.00	187.	11.8	101.	29.07	.29	1.00
	37.00	186.	7.57	101.	28.89	.29	1.00
	38.00	188.	14.4	103.	28.96	.28	1.00
	39.00	188.	11.9	98.7	29.74	.30	1.00
	40.00	198.	16.0	101.	28.69	.29	1.00
MIN		184.	0	98.7	27.32	.27	1.00
MAX		201.	28.8	103.	30.57	.31	1.00
MEAN		191.	11.8	100.	28.980	.2890	1.0000

INDIRECT PARAMETERS OF GENERATED REQUIREMENTS VECTORS

GENERATOR	VECTOR NBR	MAX	MIN	MEAN	STD DEV	COEFF OF VAR	FREQ OF OCCUR
BLACKBURN & MILLEN (CV=.72)							
	41.00	299.	0	97.3	74.97	.77	.77
	42.00	273.	0	97.1	72.95	.75	.78
	43.00	311.	0	101.	72.78	.72	.79
	44.00	309.	0	99.3	71.24	.72	.80
	45.00	354.	0	106.	73.30	.69	.80
	46.00	344.	0	100.	73.98	.74	.78
	47.00	308.	0	96.9	71.93	.74	.78
	48.00	285.	0	99.0	70.39	.71	.80
	49.00	325.	0	97.1	73.91	.76	.77
	50.00	325.	0	105.	73.41	.70	.80
MIN		273.	0	96.9	70.39	.69	.77
MAX		354.	0	106.	74.97	.77	.80
MEAN		313.	0	99.9	72.886	.7300	.7870
BLACKBURN & MILLEN (CV=1.14)							
	51.00	510.	0	108.	120.81	1.12	.61
	52.00	485.	0	94.3	110.17	1.17	.61
	53.00	532.	0	91.2	110.77	1.21	.58
	54.00	470.	0	106.	112.47	1.06	.64
	55.00	628.	0	98.2	113.67	1.16	.62
	56.00	535.	0	95.7	115.78	1.21	.60
	57.00	518.	0	96.2	115.44	1.20	.59
	58.00	475.	0	97.3	109.30	1.12	.63
	59.00	455.	0	96.7	112.58	1.16	.60
	60.00	622.	0	99.4	114.35	1.15	.62
MIN		455.	0	91.2	109.30	1.06	.58
MAX		628.	0	108.	120.81	1.21	.64
MEAN		523.	0	98.3	113.53	1.1560	.6100

INDIRECT PARAMETERS OF GENERATED REQUIREMENTS VECTORS

GENERATOR	VECTOR NBR	MAX	MIN	MEAN	STD DEV	COEFF OF VAR	FREQ OF OCCUR
WEMMERLOV (CV=.29)							
	61.00	193.	5.67	98.7	28.74	.29	1.00
	62.00	184.	5.53	101.	28.53	.28	1.00
	63.00	197.	16.9	102.	29.29	.29	1.00
	64.00	201.	28.8	99.4	27.32	.27	1.00
	65.00	189.	0	99.5	30.57	.31	1.00
	66.00	187.	11.8	101.	29.07	.29	1.00
	67.00	186.	7.57	101.	28.89	.29	1.00
	68.00	188.	14.4	103.	28.96	.28	1.00
	69.00	188.	11.9	98.7	29.74	.30	1.00
	70.00	198.	16.0	101.	28.69	.29	1.00
MIN		184.	0	98.7	27.32	.27	1.00
MAX		201.	28.8	103.	30.57	.31	1.00
MEAN		191.	11.8	100.	28.980	.2890	1.0000
WEMMERLOV (CV=.72)							
	71.00	332.	0	102.	76.53	.75	.87
	72.00	348.	0	97.0	71.74	.74	.85
	73.00	346.	0	98.3	71.37	.73	.89
	74.00	406.	0	102.	73.70	.72	.88
	75.00	393.	0	96.6	75.25	.78	.89
	76.00	344.	0	100.	70.59	.70	.90
	77.00	319.	0	100.	72.69	.72	.89
	78.00	368.	0	103.	75.55	.73	.88
	79.00	325.	0	104.	74.56	.72	.89
	80.00	337.	0	93.8	69.25	.74	.88
MIN		319.	0	93.8	69.25	.70	.85
MAX		406.	0	104.	76.53	.78	.90
MEAN		352.	0	99.7	73.123	.7330	.8820

INDIRECT PARAMETERS OF GENERATED REQUIREMENTS VECTORS

GENERATOR	VECTOR NBR	MAX	MIN	MEAN	STD DEV	COEFF OF VAR	FREQ OF OCCUR
WEMMERLOV (CV=1.14)							
	81.00	465.	0	104.	111.74	1.07	.67
	82.00	659.	0	96.5	113.95	1.18	.64
	83.00	552.	0	96.5	116.27	1.20	.62
	84.00	558.	0	105.	120.87	1.15	.66
	85.00	483.	0	93.4	110.66	1.18	.61
	86.00	652.	0	94.0	112.47	1.20	.64
	87.00	458.	0	105.	111.54	1.06	.67
	88.00	480.	0	101.	111.85	1.11	.67
	89.00	493.	0	96.4	112.60	1.17	.63
	90.00	549.	0	97.9	110.29	1.13	.67
MIN		458.	0	93.4	110.29	1.06	.61
MAX		659.	0	105.	120.87	1.20	.67
MEAN		535.	0	99.0	113.22	1.1450	.6480

APPENDIX E

Setup, Holding and Total Cost for each Requirements Vector and lot sizing algorithm simulated.

- - VECTOR 1 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	98687.00	198687.00
SILVER AND MEAL	88400.00	107933.00	196333.00
GROFF	91600.00	105521.00	197121.00
- - VECTOR 2 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100194.00	200194.00
SILVER AND MEAL	88000.00	107612.00	195612.00
GROFF	92000.00	103991.00	195991.00
- - VECTOR 3 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100816.00	200816.00
SILVER AND MEAL	88400.00	110253.00	198653.00
GROFF	93200.00	105282.00	198482.00
- - VECTOR 4 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	98767.00	198767.00
SILVER AND MEAL	90000.00	106081.00	196081.00
GROFF	93200.00	103072.00	196272.00
- - VECTOR 5 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	99573.00	199573.00
SILVER AND MEAL	89600.00	108096.00	197696.00
GROFF	92800.00	104054.00	196854.00
- - VECTOR 6 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100051.00	200051.00
SILVER AND MEAL	88400.00	110653.00	199053.00
GROFF	92800.00	105635.00	198435.00
- - VECTOR 7 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100039.00	200039.00
SILVER AND MEAL	87200.00	109813.00	197013.00
GROFF	93200.00	104277.00	197477.00
- - VECTOR 8 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100515.00	200515.00
SILVER AND MEAL	88800.00	109641.00	198441.00
GROFF	92800.00	105297.00	198097.00
- - VECTOR 9 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	101513.00	201513.00
SILVER AND MEAL	88000.00	111254.00	199254.00
GROFF	93200.00	106037.00	199237.00
- - VECTOR 10 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100156.00	200156.00
SILVER AND MEAL	88800.00	108744.00	197544.00
GROFF	93200.00	104126.00	197326.00
- - VECTOR 11 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	94400.00	103702.00	198102.00
SILVER AND MEAL	85600.00	97160.00	182760.00
GROFF	88000.00	95092.00	183092.00
- - VECTOR 12 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	88800.00	96054.00	184854.00
SILVER AND MEAL	83600.00	90978.00	174578.00
GROFF	85200.00	89341.00	174541.00
- - VECTOR 13 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	88400.00	105564.00	193964.00
SILVER AND MEAL	83200.00	95836.00	179036.00
GROFF	84800.00	94720.00	179520.00

- - VECTOR 14 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	97200.00	91014.00	188214.00
SILVER AND MEAL	83600.00	88742.00	172342.00
GROFF	85600.00	87024.00	172624.00
- - VECTOR 15 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	95200.00	88047.00	183247.00
SILVER AND MEAL	81200.00	87712.00	168912.00
GROFF	82000.00	85898.00	167898.00
- - VECTOR 16 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	94400.00	100123.00	194523.00
SILVER AND MEAL	82800.00	98100.00	180900.00
GROFF	84400.00	95866.00	180266.00
- - VECTOR 17 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	94400.00	89823.00	184223.00
SILVER AND MEAL	77200.00	89393.00	166593.00
GROFF	79600.00	87312.00	166912.00
- - VECTOR 18 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	89200.00	99056.00	188256.00
SILVER AND MEAL	85200.00	93787.00	178987.00
GROFF	87200.00	91195.00	178395.00
- - VECTOR 19 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	92800.00	96993.00	189793.00
SILVER AND MEAL	84800.00	92869.00	177669.00
GROFF	85200.00	92777.00	177977.00
- - VECTOR 20 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	94800.00	97146.00	191946.00
SILVER AND MEAL	81600.00	93851.00	175451.00
GROFF	81200.00	93714.00	174914.00
- - VECTOR 21 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	66800.00	92331.00	159131.00
SILVER AND MEAL	80000.00	64527.00	144527.00
GROFF	78800.00	64755.00	143555.00
- - VECTOR 22 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	70000.00	91322.00	161322.00
SILVER AND MEAL	78400.00	68418.00	146818.00
GROFF	78000.00	68508.00	146508.00
- - VECTOR 23 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	71600.00	96773.00	168373.00
SILVER AND MEAL	82000.00	69385.00	151385.00
GROFF	81600.00	69133.00	150733.00
- - VECTOR 24 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	77600.00	91159.00	168759.00
SILVER AND MEAL	84400.00	71883.00	156283.00
GROFF	84400.00	71847.00	156247.00
- - VECTOR 25 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	69600.00	87541.00	157141.00
SILVER AND MEAL	77200.00	66749.00	143949.00
GROFF	77600.00	66471.00	144071.00
- - VECTOR 26 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	70000.00	95071.00	165071.00
SILVER AND MEAL	82800.00	70387.00	153187.00
GROFF	82400.00	70283.00	152683.00

- - VECTOR 27 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	70400.00	92871.00	163271.00
SILVER AND MEAL	77600.00	68946.00	146546.00
GROFF	76400.00	69343.00	145743.00
- - VECTOR 28 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	80400.00	83701.00	164101.00
SILVER AND MEAL	82000.00	66213.00	148213.00
GROFF	82800.00	65589.00	148389.00
- - VECTOR 29 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	60000.00	86600.00	146600.00
SILVER AND MEAL	74000.00	61972.00	135972.00
GROFF	74000.00	61853.00	135853.00
- - VECTOR 30 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	72000.00	98451.00	170451.00
SILVER AND MEAL	85200.00	69752.00	154952.00
GROFF	85200.00	69486.00	154686.00
- - VECTOR 31 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	98780.00	198780.00
SILVER AND MEAL	90800.00	104240.00	195040.00
GROFF	94000.00	101678.00	195678.00
- - VECTOR 32 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100838.00	200838.00
SILVER AND MEAL	90000.00	108622.00	198622.00
GROFF	94400.00	104274.00	198674.00
- - VECTOR 33 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	101524.00	201524.00
SILVER AND MEAL	91200.00	108031.00	199231.00
GROFF	94800.00	104073.00	198873.00
- - VECTOR 34 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100105.00	200105.00
SILVER AND MEAL	90000.00	107347.00	197347.00
GROFF	94400.00	102709.00	197109.00
- - VECTOR 35 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	99286.00	199286.00
SILVER AND MEAL	89200.00	108376.00	197576.00
GROFF	94000.00	102512.00	196512.00
- - VECTOR 36 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100461.00	200461.00
SILVER AND MEAL	89600.00	109108.00	198708.00
GROFF	94000.00	104028.00	198028.00
- - VECTOR 37 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100660.00	200660.00
SILVER AND MEAL	91600.00	106918.00	198518.00
GROFF	94400.00	103652.00	198052.00
- - VECTOR 38 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	102812.00	202812.00
SILVER AND MEAL	92000.00	107910.00	199910.00
GROFF	95200.00	103978.00	199178.00
- - VECTOR 39 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	98463.00	198463.00
SILVER AND MEAL	90000.00	107058.00	197058.00
GROFF	95200.00	101516.00	196716.00

- - VECTOR 40 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	99445.00	199445.00
SILVER AND MEAL	91600.00	106699.00	198299.00
GROFF	94400.00	103700.00	198100.00
- - VECTOR 41 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	83600.00	92637.00	176237.00
SILVER AND MEAL	82800.00	87112.00	169912.00
GROFF	84800.00	84420.00	169220.00
- - VECTOR 42 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	82800.00	93147.00	175947.00
SILVER AND MEAL	82400.00	87537.00	169937.00
GROFF	84400.00	85667.00	170067.00
- - VECTOR 43 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	88000.00	96285.00	184285.00
SILVER AND MEAL	83600.00	94175.00	177775.00
GROFF	86000.00	91585.00	177585.00
- - VECTOR 44 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	96000.00	90317.00	186317.00
SILVER AND MEAL	84000.00	91718.00	175718.00
GROFF	87200.00	88863.00	176063.00
- - VECTOR 45 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	95200.00	95422.00	190622.00
SILVER AND MEAL	88400.00	94040.00	182440.00
GROFF	88000.00	94086.00	182086.00
- - VECTOR 46 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	84400.00	97242.00	181642.00
SILVER AND MEAL	84800.00	91462.00	176262.00
GROFF	88000.00	87868.00	175868.00
- - VECTOR 47 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	81600.00	95287.00	176887.00
SILVER AND MEAL	82000.00	88836.00	170836.00
GROFF	81600.00	88826.00	170426.00
- - VECTOR 48 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	90400.00	92085.00	182485.00
SILVER AND MEAL	82400.00	93764.00	176164.00
GROFF	86000.00	89958.00	175958.00
- - VECTOR 49 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	84800.00	92191.00	176991.00
SILVER AND MEAL	82400.00	87807.00	170207.00
GROFF	83200.00	87365.00	170565.00
- - VECTOR 50 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	94800.00	96714.00	191514.00
SILVER AND MEAL	88800.00	93594.00	182394.00
GROFF	88800.00	93210.00	182010.00
- - VECTOR 51 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	73600.00	95996.00	169596.00
SILVER AND MEAL	81200.00	74366.00	155566.00
GROFF	80800.00	74666.00	155466.00
- - VECTOR 52 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	72000.00	84821.00	156821.00
SILVER AND MEAL	76400.00	67003.00	143403.00
GROFF	76000.00	67129.00	143129.00

- - VECTOR 53 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	68000.00	85886.00	153886.00
SILVER AND MEAL	78400.00	62796.00	141196.00
GROFF	78000.00	62524.00	140524.00
- - VECTOR 54 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	82800.00	88600.00	171400.00
SILVER AND MEAL	81600.00	76754.00	158354.00
GROFF	82000.00	76418.00	158418.00
- - VECTOR 55 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	75600.00	88586.00	164186.00
SILVER AND MEAL	74000.00	73815.00	147815.00
GROFF	74800.00	73046.00	147846.00
- - VECTOR 56 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	72000.00	87062.00	159062.00
SILVER AND MEAL	75600.00	68586.00	144186.00
GROFF	76800.00	67273.00	144073.00
- - VECTOR 57 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	68800.00	87755.00	156555.00
SILVER AND MEAL	74800.00	68261.00	143061.00
GROFF	75200.00	67883.00	143083.00
- - VECTOR 58 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	74800.00	85661.00	160461.00
SILVER AND MEAL	79200.00	69123.00	148323.00
GROFF	79200.00	69143.00	148343.00
- - VECTOR 59 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	72000.00	85532.00	157532.00
SILVER AND MEAL	75200.00	69026.00	144226.00
GROFF	75600.00	68642.00	144242.00
- - VECTOR 60 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	74400.00	87291.00	161691.00
SILVER AND MEAL	79200.00	71217.00	150417.00
GROFF	78800.00	71509.00	150309.00
- - VECTOR 61 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	98780.00	198780.00
SILVER AND MEAL	90800.00	104240.00	195040.00
GROFF	94000.00	101678.00	195678.00
- - VECTOR 62 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100838.00	200838.00
SILVER AND MEAL	90000.00	108622.00	198622.00
GROFF	94400.00	104274.00	198674.00
- - VECTOR 63 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	101524.00	201524.00
SILVER AND MEAL	91200.00	108031.00	199231.00
GROFF	94800.00	104073.00	198873.00
- - VECTOR 64 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100105.00	200105.00
SILVER AND MEAL	90000.00	107347.00	197347.00
GROFF	94400.00	102709.00	197109.00
- - VECTOR 65 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	99290.00	199290.00
SILVER AND MEAL	88800.00	108765.00	197565.00
GROFF	94000.00	102614.00	196614.00

- - VECTOR 66 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100461.00	200461.00
SILVER AND MEAL	89600.00	109108.00	198708.00
GROFF	94000.00	104028.00	198028.00
- - VECTOR 67 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	100660.00	200660.00
SILVER AND MEAL	91600.00	106918.00	198518.00
GROFF	94400.00	103652.00	198052.00
- - VECTOR 68 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	102812.00	202812.00
SILVER AND MEAL	92000.00	107910.00	199910.00
GROFF	95200.00	103978.00	199178.00
- - VECTOR 69 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	98463.00	198463.00
SILVER AND MEAL	90000.00	107058.00	197058.00
GROFF	95200.00	101516.00	196716.00
- - VECTOR 70 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	100000.00	99445.00	199445.00
SILVER AND MEAL	91600.00	106699.00	198299.00
GROFF	94400.00	103700.00	198100.00
- - VECTOR 71 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	87600.00	102247.00	189847.00
SILVER AND MEAL	86000.00	91552.00	177552.00
GROFF	86800.00	90024.00	176824.00
- - VECTOR 72 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	91600.00	94324.00	185924.00
SILVER AND MEAL	84000.00	91146.00	175146.00
GROFF	84400.00	89546.00	173946.00
- - VECTOR 73 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	94000.00	93506.00	187506.00
SILVER AND MEAL	82400.00	91894.00	174294.00
GROFF	82400.00	91008.00	173408.00
- - VECTOR 74 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	90400.00	100604.00	191004.00
SILVER AND MEAL	86400.00	91997.00	178397.00
GROFF	87200.00	91279.00	178479.00
- - VECTOR 75 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	97600.00	93272.00	190872.00
SILVER AND MEAL	83200.00	88363.00	171563.00
GROFF	84400.00	87129.00	171529.00
- - VECTOR 76 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	96000.00	97872.00	193872.00
SILVER AND MEAL	83600.00	94696.00	178296.00
GROFF	86000.00	91774.00	177774.00
- - VECTOR 77 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	96000.00	96222.00	192222.00
SILVER AND MEAL	83200.00	95298.00	178498.00
GROFF	84800.00	93466.00	178266.00
- - VECTOR 78 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	94400.00	98739.00	193139.00
SILVER AND MEAL	85600.00	94751.00	180351.00
GROFF	87200.00	92441.00	179641.00

- - VECTOR 79 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	97200.00	99541.00	196741.00
SILVER AND MEAL	87200.00	94053.00	181253.00
GROFF	88800.00	91991.00	180791.00
- - VECTOR 80 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	92800.00	92388.00	185188.00
SILVER AND MEAL	81600.00	89728.00	171328.00
GROFF	84000.00	86925.00	170925.00
- - VECTOR 81 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	85600.00	91660.00	177260.00
SILVER AND MEAL	82400.00	75771.00	158171.00
GROFF	81200.00	76253.00	157453.00
- - VECTOR 82 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	78800.00	85308.00	164108.00
SILVER AND MEAL	80000.00	69304.00	149304.00
GROFF	78000.00	70598.00	148598.00
- - VECTOR 83 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	73600.00	88224.00	161824.00
SILVER AND MEAL	79200.00	66316.00	145516.00
GROFF	79200.00	66194.00	145394.00
- - VECTOR 84 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	88000.00	87163.00	175163.00
SILVER AND MEAL	80400.00	75413.00	155813.00
GROFF	81600.00	73957.00	155557.00
- - VECTOR 85 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	74800.00	82874.00	157674.00
SILVER AND MEAL	76400.00	66896.00	143296.00
GROFF	76400.00	66872.00	143272.00
- - VECTOR 86 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	81600.00	80020.00	161620.00
SILVER AND MEAL	76400.00	68400.00	144800.00
GROFF	76800.00	67939.00	144739.00
- - VECTOR 87 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	86000.00	89412.00	175412.00
SILVER AND MEAL	83600.00	75821.00	159421.00
GROFF	83600.00	75345.00	158945.00
- - VECTOR 88 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	89200.00	84933.00	174133.00
SILVER AND MEAL	79600.00	75317.00	154917.00
GROFF	80400.00	74527.00	154927.00
- - VECTOR 89 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	78000.00	83728.00	161728.00
SILVER AND MEAL	73600.00	71486.00	145086.00
GROFF	74000.00	70937.00	144937.00
- - VECTOR 90 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	81600.00	87639.00	169239.00
SILVER AND MEAL	78800.00	73394.00	152194.00
GROFF	78400.00	72772.00	151172.00

- - VECTOR 1 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	98687.00	198687.00
SILVER AND MEAL	88400.00	107933.00	196333.00
GROFF	91600.00	105521.00	197121.00

- - VECTOR 2 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100194 00	200194.00
SILVER AND MEAL	88000.00	107612.00	195612.00
GROFF	92000.00	103991.00	195991.00
- - VECTOR 3 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100816.00	200816.00
SILVER AND MEAL	88400.00	110253.00	198653.00
GROFF	93200.00	105282.00	198482.00
- - VECTOR 4 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	98767.00	198767.00
SILVER AND MEAL	90000.00	106081.00	196081.00
GROFF	93200.00	103072.00	196272.00
- - VECTOR 5 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	99573.00	199573.00
SILVER AND MEAL	89600.00	108096.00	197696.00
GROFF	92800.00	104054.00	196854.00
- - VECTOR 6 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100051.00	200051.00
SILVER AND MEAL	88400.00	110653.00	199053.00
GROFF	92800.00	105635.00	198435.00
- - VECTOR 7 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100039.00	200039.00
SILVER AND MEAL	87200.00	109813.00	197013.00
GROFF	93200.00	104277.00	197477.00
- - VECTOR 8 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100515.00	200515.00
SILVER AND MEAL	88800.00	109641.00	198441.00
GROFF	92800.00	105297.00	198097.00
- - VECTOR 9 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	101513.00	201513.00
SILVER AND MEAL	88000.00	111254.00	199254.00
GROFF	93200.00	106037.00	199237.00
- - VECTOR 10 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100156.00	200156.00
SILVER AND MEAL	88800.00	108744.00	197544.00
GROFF	93200.00	104126.00	197326.00
- - VECTOR 11 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	94000.00	100526.00	194526.00
SILVER AND MEAL	84000.00	97992.00	181992.00
GROFF	86400.00	95504.00	181904.00
- - VECTOR 12 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	88400.00	99746.00	188146.00
SILVER AND MEAL	80000.00	93624.00	173624.00
GROFF	82400.00	91271.00	173671.00
- - VECTOR 13 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	88800.00	103976.00	192776.00
SILVER AND MEAL	81600.00	98180.00	179780.00
GROFF	83600.00	96038.00	179638.00
- - VECTOR 14 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	90800.00	95076.00	185876.00
SILVER AND MEAL	80000.00	91064.00	171064.00
GROFF	82400.00	88728.00	171128.00

- - VECTOR 15 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	87200.00	92563.00	179763.00
SILVER AND MEAL	78400.00	91066.00	169466.00
GROFF	82000.00	87916.00	169916.00
- - VECTOR 16 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	91600.00	103041.00	194641.00
SILVER AND MEAL	80800.00	98464.00	179264.00
GROFF	82000.00	97026.00	179026.00
- - VECTOR 17 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	88800.00	93639.00	182439.00
SILVER AND MEAL	76800.00	90879.00	167679.00
GROFF	78000.00	90116.00	168116.00
- - VECTOR 18 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	88000.00	99742.00	187742.00
SILVER AND MEAL	83200.00	94451.00	177651.00
GROFF	85200.00	91695.00	176895.00
- - VECTOR 19 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	92400.00	98711.00	191111.00
SILVER AND MEAL	82400.00	95149.00	177549.00
GROFF	84000.00	94039.00	178039.00
- - VECTOR 20 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	93600.00	97242.00	190842.00
SILVER AND MEAL	79200.00	95555.00	174755.00
GROFF	79600.00	94712.00	174312.00
- - VECTOR 21 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	65600.00	90741.00	156341.00
SILVER AND MEAL	75200.00	66899.00	142099.00
GROFF	75200.00	66887.00	142087.00
- - VECTOR 22 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	70800.00	90082.00	160882.00
SILVER AND MEAL	72400.00	72634.00	145034.00
GROFF	72400.00	72184.00	144584.00
- - VECTOR 23 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	72800.00	91809.00	164609.00
SILVER AND MEAL	75600.00	72181.00	147781.00
GROFF	77200.00	70925.00	148125.00
- - VECTOR 24 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	72800.00	104787.00	177587.00
SILVER AND MEAL	81200.00	74975.00	156175.00
GROFF	81600.00	74393.00	155993.00
- - VECTOR 25 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	69600.00	87439.00	157039.00
SILVER AND MEAL	70800.00	71365.00	142165.00
GROFF	72400.00	70123.00	142523.00
- - VECTOR 26 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	70800.00	94869.00	165669.00
SILVER AND MEAL	76800.00	74081.00	150881.00
GROFF	77600.00	73273.00	150873.00
- - VECTOR 27 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	70000.00	92869.00	162869.00
SILVER AND MEAL	76800.00	68870.00	145670.00
GROFF	76400.00	68457.00	144857.00

- - VECTOR 28 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	66400.00	95041.00	161441.00
SILVER AND MEAL	74400.00	71847.00	146247.00
GROFF	75200.00	70547.00	145747.00
- - VECTOR 29 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	58800.00	87124.00	145924.00
SILVER AND MEAL	68000.00	65258.00	133258.00
GROFF	68000.00	65075.00	133075.00
- - VECTOR 30 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	72800.00	95845.00	168645.00
SILVER AND MEAL	81200.00	72392.00	153592.00
GROFF	81600.00	71818.00	153418.00
- - VECTOR 31 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	98780.00	198780.00
SILVER AND MEAL	90800.00	104240.00	195040.00
GROFF	94000.00	101678.00	195678.00
- - VECTOR 32 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100838.00	200838.00
SILVER AND MEAL	90000.00	108622.00	198622.00
GROFF	94400.00	104274.00	198674.00
- - VECTOR 33 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	101524.00	201524.00
SILVER AND MEAL	91200.00	108031.00	199231.00
GROFF	94800.00	104073.00	198873.00
- - VECTOR 34 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100105.00	200105.00
SILVER AND MEAL	90000.00	107347.00	197347.00
GROFF	94400.00	102709.00	197109.00
- - VECTOR 35 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	99004.00	199004.00
SILVER AND MEAL	88800.00	108378.00	197178.00
GROFF	94000.00	102226.00	196226.00
- - VECTOR 36 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100461.00	200461.00
SILVER AND MEAL	89600.00	109108.00	198708.00
GROFF	94000.00	104028.00	198028.00
- - VECTOR 37 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100660.00	200660.00
SILVER AND MEAL	91600.00	106918.00	198518.00
GROFF	94400.00	103652.00	198052.00
- - VECTOR 38 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	102812.00	202812.00
SILVER AND MEAL	92000.00	107910.00	199910.00
GROFF	95200.00	103978.00	199178.00
- - VECTOR 39 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	98463.00	198463.00
SILVER AND MEAL	90000.00	107058.00	197058.00
GROFF	95200.00	101516.00	196716.00
- - VECTOR 40 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	99445.00	199445.00
SILVER AND MEAL	91600.00	106699.00	198299.00
GROFF	94400.00	103700.00	198100.00

- - VECTOR 41 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	83200.00	95915.00	179115.00
SILVER AND MEAL	80400.00	89230.00	169630.00
GROFF	81600.00	87238.00	168838.00
- - VECTOR 42 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	82800.00	92745.00	175545.00
SILVER AND MEAL	78000.00	90933.00	168933.00
GROFF	79200.00	89871.00	169071.00
- - VECTOR 43 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	87200.00	97417.00	184617.00
SILVER AND MEAL	80000.00	96067.00	176067.00
GROFF	82000.00	93715.00	175715.00
- - VECTOR 44 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	80000.00	99113.00	179113.00
SILVER AND MEAL	80000.00	94814.00	174814.00
GROFF	83200.00	91991.00	175191.00
- - VECTOR 45 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	81600.00	105248.00	186848.00
SILVER AND MEAL	86000.00	95018.00	181018.00
GROFF	86400.00	94578.00	180978.00
- - VECTOR 46 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	86000.00	95376.00	181376.00
SILVER AND MEAL	79200.00	95224.00	174424.00
GROFF	81600.00	92334.00	173934.00
- - VECTOR 47 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	80400.00	95443.00	175843.00
SILVER AND MEAL	80800.00	89002.00	169802.00
GROFF	82800.00	87464.00	170264.00
- - VECTOR 48 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	83200.00	95897.00	179097.00
SILVER AND MEAL	77200.00	97214.00	174414.00
GROFF	82800.00	91776.00	174576.00
- - VECTOR 49 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	82800.00	95707.00	178507.00
SILVER AND MEAL	77600.00	91785.00	169385.00
GROFF	78000.00	90845.00	168845.00
- - VECTOR 50 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	82000.00	99866.00	181866.00
SILVER AND MEAL	82400.00	96850.00	179250.00
GROFF	83200.00	95770.00	178970.00
- - VECTOR 51 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	73200.00	97780.00	170980.00
SILVER AND MEAL	78800.00	76014.00	154814.00
GROFF	78800.00	75884.00	154684.00
- - VECTOR 52 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	72000.00	83629.00	155629.00
SILVER AND MEAL	69600.00	71459.00	141059.00
GROFF	70800.00	70161.00	140961.00
- - VECTOR 53 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	68400.00	83524.00	151924.00
SILVER AND MEAL	70000.00	67732.00	137732.00
GROFF	70400.00	66094.00	136494.00

- - VECTOR 54 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	67200.00	101698.00	168898.00
SILVER AND MEAL	76400.00	79650.00	156050.00
GROFF	77600.00	78482.00	156082.00
- - VECTOR 55 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	71600.00	93468.00	165068.00
SILVER AND MEAL	71600.00	76291.00	147891.00
GROFF	73600.00	74198.00	147798.00
- - VECTOR 56 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	72000.00	88626.00	160626.00
SILVER AND MEAL	70800.00	72582.00	143382.00
GROFF	71600.00	71855.00	143455.00
- - VECTOR 57 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	70000.00	86627.00	156627.00
SILVER AND MEAL	68800.00	71933.00	140733.00
GROFF	69600.00	71189.00	140789.00
- - VECTOR 58 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	74800.00	89555.00	164355.00
SILVER AND MEAL	75200.00	71959.00	147159.00
GROFF	75600.00	71443.00	147043.00
- - VECTOR 59 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	71600.00	87156.00	158756.00
SILVER AND MEAL	72400.00	72140.00	144540.00
GROFF	73200.00	71428.00	144628.00
- - VECTOR 60 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	73200.00	90589.00	163789.00
SILVER AND MEAL	72000.00	75669.00	147669.00
GROFF	72800.00	75057.00	147857.00
- - VECTOR 61 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	98780.00	198780.00
SILVER AND MEAL	90800.00	104240.00	195040.00
GROFF	94000.00	101678.00	195678.00
- - VECTOR 62 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100838.00	200838.00
SILVER AND MEAL	90000.00	108622.00	198622.00
GROFF	94400.00	104274.00	198674.00
- - VECTOR 63 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	101524.00	201524.00
SILVER AND MEAL	91200.00	108031.00	199231.00
GROFF	94800.00	104073.00	198873.00
- - VECTOR 64 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100105.00	200105.00
SILVER AND MEAL	90000.00	107347.00	197347.00
GROFF	94400.00	102709.00	197109.00
- - VECTOR 65 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	99004.00	199004.00
SILVER AND MEAL	88800.00	108378.00	197178.00
GROFF	94000.00	102226.00	196226.00
- - VECTOR 66 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100461.00	200461.00
SILVER AND MEAL	89600.00	109108.00	198708.00
GROFF	94000.00	104028.00	198028.00

- - VECTOR 67 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	100660.00	200660.00
SILVER AND MEAL	91600.00	106918.00	198518.00
GROFF	94400.00	103652.00	198052.00
- - VECTOR 68 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	102812.00	202812.00
SILVER AND MEAL	92000.00	107910.00	199910.00
GROFF	95200.00	103978.00	199178.00
- - VECTOR 69 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	98463.00	198463.00
SILVER AND MEAL	90000.00	107058.00	197058.00
GROFF	95200.00	101516.00	196716.00
- - VECTOR 70 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	100000.00	99445.00	199445.00
SILVER AND MEAL	91600.00	106699.00	198299.00
GROFF	94400.00	103700.00	198100.00
- - VECTOR 71 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	88000.00	100573.00	188573.00
SILVER AND MEAL	84000.00	93068.00	177068.00
GROFF	85200.00	91266.00	176466.00
- - VECTOR 72 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	91600.00	92812.00	184412.00
SILVER AND MEAL	80400.00	93746.00	174146.00
GROFF	82000.00	92272.00	174272.00
- - VECTOR 73 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	94000.00	97268.00	191268.00
SILVER AND MEAL	80400.00	94406.00	174806.00
GROFF	82000.00	91584.00	173584.00
- - VECTOR 74 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	89600.00	99538.00	189138.00
SILVER AND MEAL	81200.00	96801.00	178001.00
GROFF	84000.00	94185.00	178185.00
- - VECTOR 75 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	89600.00	95286.00	184886.00
SILVER AND MEAL	82400.00	88725.00	171125.00
GROFF	82800.00	88423.00	171223.00
- - VECTOR 76 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	92800.00	98714.00	191514.00
SILVER AND MEAL	80800.00	97010.00	177810.00
GROFF	84400.00	93618.00	178018.00
- - VECTOR 77 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	92000.00	99948.00	191948.00
SILVER AND MEAL	82000.00	95480.00	177480.00
GROFF	84000.00	93230.00	177230.00
- - VECTOR 78 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	92800.00	100451.00	193251.00
SILVER AND MEAL	84800.00	94851.00	179651.00
GROFF	85200.00	94347.00	179547.00
- - VECTOR 79 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	90000.00	101213.00	191213.00
SILVER AND MEAL	87600.00	93561.00	181161.00
GROFF	89600.00	91023.00	180623.00

- - VECTOR 80 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	92400.00	91764.00	184164.00
SILVER AND MEAL	80000.00	90134.00	170134.00
GROFF	82400.00	87313.00	169713.00
- - VECTOR 81 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	71200.00	98678.00	169878.00
SILVER AND MEAL	77600.00	79317.00	156917.00
GROFF	77200.00	78849.00	156049.00
- - VECTOR 82 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	72400.00	87682.00	160082.00
SILVER AND MEAL	73600.00	72222.00	145822.00
GROFF	74000.00	72094.00	146094.00
- - VECTOR 83 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	74000.00	87494.00	161494.00
SILVER AND MEAL	69600.00	72544.00	142144.00
GROFF	70800.00	71768.00	142568.00
- - VECTOR 84 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	66000.00	105021.00	171021.00
SILVER AND MEAL	73600.00	79227.00	152827.00
GROFF	74800.00	78253.00	153053.00
- - VECTOR 85 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	72400.00	87598.00	159998.00
SILVER AND MEAL	72400.00	70522.00	142922.00
GROFF	72400.00	70368.00	142768.00
- - VECTOR 86 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	68000.00	93034.00	161034.00
SILVER AND MEAL	68800.00	73532.00	142332.00
GROFF	70400.00	71827.00	142227.00
- - VECTOR 87 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	70800.00	102730.00	173530.00
SILVER AND MEAL	77600.00	80347.00	157947.00
GROFF	78400.00	79255.00	157655.00
- - VECTOR 88 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	68000.00	101199.00	169199.00
SILVER AND MEAL	74800.00	78069.00	152869.00
GROFF	76800.00	76029.00	152829.00
- - VECTOR 89 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	71200.00	87820.00	159020.00
SILVER AND MEAL	70800.00	73276.00	144076.00
GROFF	71200.00	72881.00	144081.00
- - VECTOR 90 - - TYPE 2 GROUPING - -			
PERIODIC ORDER	72800.00	97197.00	169997.00
SILVER AND MEAL	72000.00	77740.00	149740.00
GROFF	71600.00	77538.00	149138.00

- - VECTOR 1 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	100000.00	98687.00	198687.00
SILVER AND MEAL	88400.00	107933.00	196333.00
GROFF	91600.00	105521.00	197121.00
- - VECTOR 2 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	100000.00	100194.00	200194.00
SILVER AND MEAL	88000.00	107612.00	195612.00
GROFF	92000.00	103991.00	195991.00

- - VECTOR 3 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100816.00	200816.00
SILVER AND MEAL	88400.00	110253.00	198653.00
GROFF	93200.00	105282.00	198482.00
- - VECTOR 4 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	98767.00	198767.00
SILVER AND MEAL	90000.00	106081.00	196081.00
GROFF	93200.00	103072.00	196272.00
- - VECTOR 5 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	99573.00	199573.00
SILVER AND MEAL	89600.00	108096.00	197696.00
GROFF	92800.00	104054.00	196854.00
- - VECTOR 6 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100051.00	200051.00
SILVER AND MEAL	88400.00	110653.00	199053.00
GROFF	92800.00	105635.00	198435.00
- - VECTOR 7 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100039.00	200039.00
SILVER AND MEAL	87200.00	109813.00	197013.00
GROFF	93200.00	104277.00	197477.00
- - VECTOR 8 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100515.00	200515.00
SILVER AND MEAL	88800.00	109641.00	198441.00
GROFF	92800.00	105297.00	198097.00
- - VECTOR 9 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	101513.00	201513.00
SILVER AND MEAL	88000.00	111254.00	199254.00
GROFF	93200.00	106037.00	199237.00
- - VECTOR 10 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100156.00	200156.00
SILVER AND MEAL	88800.00	108744.00	197544.00
GROFF	93200.00	104126.00	197326.00
- - VECTOR 11 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	94400.00	100156.00	194556.00
SILVER AND MEAL	86800.00	95956.00	182756.00
GROFF	89200.00	93884.00	183084.00
- - VECTOR 12 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	93200.00	95970.00	189170.00
SILVER AND MEAL	83600.00	90096.00	173696.00
GROFF	84800.00	89029.00	173829.00
- - VECTOR 13 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	94000.00	99996.00	193996.00
SILVER AND MEAL	86000.00	92726.00	178726.00
GROFF	87600.00	91412.00	179012.00
- - VECTOR 14 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	93600.00	95390.00	188990.00
SILVER AND MEAL	81200.00	91412.00	172612.00
GROFF	82800.00	90002.00	172802.00
- - VECTOR 15 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	92800.00	90191.00	182991.00
SILVER AND MEAL	80400.00	89262.00	169662.00
GROFF	82400.00	87456.00	169856.00

- - VECTOR 16 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	93600.00	101049.00	194649.00
SILVER AND MEAL	83200.00	96544.00	179744.00
GROFF	82800.00	96496.00	179296.00
- - VECTOR 17 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	91600.00	93087.00	184687.00
SILVER AND MEAL	80000.00	89269.00	169269.00
GROFF	82000.00	86738.00	168738.00
- - VECTOR 18 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	92400.00	99628.00	192028.00
SILVER AND MEAL	84800.00	95049.00	179849.00
GROFF	86800.00	91545.00	178345.00
- - VECTOR 19 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	94400.00	96209.00	190609.00
SILVER AND MEAL	85200.00	93319.00	178519.00
GROFF	86000.00	92701.00	178701.00
- - VECTOR 20 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	92400.00	97336.00	189736.00
SILVER AND MEAL	81600.00	93461.00	175061.00
GROFF	82000.00	92498.00	174498.00
- - VECTOR 21 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	73600.00	84961.00	158561.00
SILVER AND MEAL	81200.00	63781.00	144981.00
GROFF	81200.00	63577.00	144777.00
- - VECTOR 22 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	74800.00	85688.00	160488.00
SILVER AND MEAL	80800.00	66966.00	147766.00
GROFF	80400.00	67190.00	147590.00
- - VECTOR 23 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	77200.00	90893.00	168093.00
SILVER AND MEAL	86000.00	66977.00	152977.00
GROFF	84800.00	67161.00	151961.00
- - VECTOR 24 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	77600.00	94167.00	171767.00
SILVER AND MEAL	88000.00	70773.00	158773.00
GROFF	86000.00	71973.00	157973.00
- - VECTOR 25 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	71600.00	79889.00	151489.00
SILVER AND MEAL	79200.00	63625.00	142825.00
GROFF	79200.00	63665.00	142865.00
- - VECTOR 26 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	74000.00	94393.00	168393.00
SILVER AND MEAL	84000.00	69371.00	153371.00
GROFF	83200.00	69839.00	153039.00
- - VECTOR 27 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	75600.00	86601.00	162201.00
SILVER AND MEAL	78000.00	68024.00	146024.00
GROFF	78400.00	67383.00	145783.00
- - VECTOR 28 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	76400.00	89933.00	166333.00
SILVER AND MEAL	82000.00	67249.00	149249.00
GROFF	81600.00	67143.00	148743.00

- - VECTOR 29 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	71600.00	77312.00	148912.00
SILVER AND MEAL	77600.00	60028.00	137628.00
GROFF	76800.00	60895.00	137695.00
- - VECTOR 30 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	74800.00	91781.00	166581.00
SILVER AND MEAL	81600.00	71784.00	153384.00
GROFF	81200.00	71770.00	152970.00
- - VECTOR 31 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	98780.00	198780.00
SILVER AND MEAL	90800.00	104240.00	195040.00
GROFF	94000.00	101678.00	195678.00
- - VECTOR 32 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100838.00	200838.00
SILVER AND MEAL	90000.00	108622.00	198622.00
GROFF	94400.00	104274.00	198674.00
- - VECTOR 33 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	101524.00	201524.00
SILVER AND MEAL	91200.00	108031.00	199231.00
GROFF	94800.00	104073.00	198873.00
- - VECTOR 34 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100105.00	200105.00
SILVER AND MEAL	90000.00	107347.00	197347.00
GROFF	94400.00	102709.00	197109.00
- - VECTOR 35 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	99290.00	199290.00
SILVER AND MEAL	88800.00	109087.00	197887.00
GROFF	94400.00	102768.00	197168.00
- - VECTOR 36 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100461.00	200461.00
SILVER AND MEAL	89600.00	109108.00	198708.00
GROFF	94000.00	104028.00	198028.00
- - VECTOR 37 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100660.00	200660.00
SILVER AND MEAL	91600.00	106918.00	198518.00
GROFF	94400.00	103652.00	198052.00
- - VECTOR 38 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	102812.00	202812.00
SILVER AND MEAL	92000.00	107910.00	199910.00
GROFF	95200.00	103978.00	199178.00
- - VECTOR 39 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	98463.00	198463.00
SILVER AND MEAL	90000.00	107058.00	197058.00
GROFF	95200.00	101516.00	196716.00
- - VECTOR 40 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	99445.00	199445.00
SILVER AND MEAL	91600.00	106699.00	198299.00
GROFF	94400.00	103700.00	198100.00
- - VECTOR 41 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	87600.00	91031.00	178631.00
SILVER AND MEAL	84800.00	86502.00	171302.00
GROFF	87600.00	83552.00	171152.00

- - VECTOR 42 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	87600.00	91513.00	179113.00
SILVER AND MEAL	85200.00	86949.00	172149.00
GROFF	86400.00	84833.00	171233.00
- - VECTOR 43 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	87200.00	96565.00	183765.00
SILVER AND MEAL	85600.00	92177.00	177777.00
GROFF	86800.00	91145.00	177945.00
- - VECTOR 44 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	90000.00	93765.00	183765.00
SILVER AND MEAL	84000.00	93160.00	177160.00
GROFF	86800.00	90405.00	177205.00
- - VECTOR 45 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	88400.00	102286.00	190686.00
SILVER AND MEAL	88400.00	95142.00	183542.00
GROFF	87600.00	95310.00	182910.00
- - VECTOR 46 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	90000.00	91460.00	181460.00
SILVER AND MEAL	85200.00	90022.00	175222.00
GROFF	88000.00	87086.00	175086.00
- - VECTOR 47 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	87600.00	89939.00	177539.00
SILVER AND MEAL	83200.00	87432.00	170632.00
GROFF	85200.00	85046.00	170246.00
- - VECTOR 48 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	88000.00	92223.00	180223.00
SILVER AND MEAL	82400.00	92226.00	174626.00
GROFF	85200.00	89612.00	174812.00
- - VECTOR 49 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	87600.00	92815.00	180415.00
SILVER AND MEAL	82000.00	87923.00	169923.00
GROFF	82800.00	87335.00	170135.00
- - VECTOR 50 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	88400.00	97754.00	186154.00
SILVER AND MEAL	86400.00	95108.00	181508.00
GROFF	88000.00	93036.00	181036.00
- - VECTOR 51 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	76000.00	97220.00	173220.00
SILVER AND MEAL	87200.00	70658.00	157858.00
GROFF	85600.00	71564.00	157164.00
- - VECTOR 52 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	76000.00	82813.00	158813.00
SILVER AND MEAL	79600.00	65843.00	145443.00
GROFF	78400.00	66361.00	144761.00
- - VECTOR 53 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	72800.00	81292.00	154092.00
SILVER AND MEAL	76000.00	65094.00	141094.00
GROFF	76000.00	64384.00	140384.00
- - VECTOR 54 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	77600.00	92672.00	170272.00
SILVER AND MEAL	84800.00	73922.00	158722.00
GROFF	84400.00	74084.00	158484.00

- - VECTOR 55 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	78000.00	82750.00	160750.00
SILVER AND MEAL	76400.00	72637.00	149037.00
GROFF	76400.00	72060.00	148460.00
- - VECTOR 56 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	75600.00	85472.00	161072.00
SILVER AND MEAL	77600.00	67264.00	144864.00
GROFF	77200.00	67401.00	144601.00
- - VECTOR 57 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	76000.00	82155.00	158155.00
SILVER AND MEAL	80800.00	64181.00	144981.00
GROFF	79600.00	64979.00	144579.00
- - VECTOR 56 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	80000.00	84477.00	164477.00
SILVER AND MEAL	83200.00	67039.00	150239.00
GROFF	84400.00	66393.00	150793.00
- - VECTOR 59 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	76400.00	85374.00	161774.00
SILVER AND MEAL	75600.00	68796.00	144396.00
GROFF	76000.00	68522.00	144522.00
- - VECTOR 60 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	78000.00	83803.00	161803.00
SILVER AND MEAL	77600.00	71065.00	148665.00
GROFF	77200.00	71211.00	148411.00
- - VECTOR 61 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	98780.00	198780.00
SILVER AND MEAL	90800.00	104240.00	195040.00
GROFF	94000.00	101678.00	195678.00
- - VECTOR 62 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100838.00	200838.00
SILVER AND MEAL	90000.00	108622.00	198622.00
GROFF	94400.00	104274.00	198674.00
- - VECTOR 63 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	101524.00	201524.00
SILVER AND MEAL	91200.00	108031.00	199231.00
GROFF	94800.00	104073.00	198873.00
- - VECTOR 64 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100105.00	200105.00
SILVER AND MEAL	90000.00	107347.00	197347.00
GROFF	94400.00	102709.00	197109.00
- - VECTOR 65 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	99290.00	199290.00
SILVER AND MEAL	88800.00	109087.00	197887.00
GROFF	94400.00	102768.00	197168.00
- - VECTOR 66 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100461.00	200461.00
SILVER AND MEAL	89600.00	109108.00	198708.00
GROFF	94000.00	104028.00	198028.00
- - VECTOR 67 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	100660.00	200660.00
SILVER AND MEAL	91600.00	106918.00	198518.00
GROFF	94400.00	103652.00	198052.00

- - VECTOR 68 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	102812.00	202812.00
SILVER AND MEAL	92000.00	107910.00	199910.00
GROFF	95200.00	103978.00	199178.00
- - VECTOR 69 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	98463.00	198463.00
SILVER AND MEAL	90000.00	107058.00	197058.00
GROFF	95200.00	101516.00	196716.00
- - VECTOR 70 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	100000.00	99445.00	199445.00
SILVER AND MEAL	91600.00	106699.00	198299.00
GROFF	94400.00	103700.00	198100.00
- - VECTOR 71 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	93200.00	98415.00	191615.00
SILVER AND MEAL	85600.00	91918.00	177518.00
GROFF	87200.00	90230.00	177430.00
- - VECTOR 72 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	92400.00	94100.00	186500.00
SILVER AND MEAL	84400.00	91166.00	175566.00
GROFF	86800.00	88140.00	174940.00
- - VECTOR 73 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	94400.00	96522.00	190922.00
SILVER AND MEAL	85200.00	90492.00	175692.00
GROFF	86000.00	89194.00	175194.00
- - VECTOR 74 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	93600.00	99258.00	192858.00
SILVER AND MEAL	88000.00	91661.00	179661.00
GROFF	88800.00	90971.00	179771.00
- - VECTOR 75 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	94800.00	94626.00	189426.00
SILVER AND MEAL	84800.00	86741.00	171541.00
GROFF	84800.00	86815.00	171615.00
- - VECTOR 76 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	94400.00	99384.00	193784.00
SILVER AND MEAL	84400.00	94692.00	179092.00
GROFF	88000.00	90636.00	178636.00
- - VECTOR 77 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	94400.00	95792.00	190192.00
SILVER AND MEAL	86400.00	92030.00	178430.00
GROFF	88000.00	90382.00	178382.00
- - VECTOR 78 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	94800.00	99515.00	194315.00
SILVER AND MEAL	87600.00	93465.00	181065.00
GROFF	88400.00	92493.00	180893.00
- - VECTOR 79 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	94400.00	98699.00	193099.00
SILVER AND MEAL	88800.00	92807.00	181607.00
GROFF	90400.00	90419.00	180819.00
- - VECTOR 80 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	93200.00	92062.00	185262.00
SILVER AND MEAL	84400.00	87750.00	172150.00
GROFF	85600.00	85651.00	171251.00

- - VECTOR 81 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	81200.00	90252.00	171452.00
SILVER AND MEAL	80800.00	76247.00	157047.00
GROFF	80800.00	76153.00	156953.00
- - VECTOR 82 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	78000.00	86758.00	164758.00
SILVER AND MEAL	77200.00	72028.00	149228.00
GROFF	76800.00	72304.00	149104.00
- - VECTOR 83 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	76000.00	87184.00	163184.00
SILVER AND MEAL	79200.00	67036.00	146236.00
GROFF	79200.00	67068.00	146268.00
- - VECTOR 84 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	78400.00	94595.00	172995.00
SILVER AND MEAL	83200.00	72415.00	155615.00
GROFF	82800.00	72543.00	155343.00
- - VECTOR 85 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	75600.00	83082.00	158682.00
SILVER AND MEAL	76400.00	68136.00	144536.00
GROFF	74800.00	69112.00	143912.00
- - VECTOR 86 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	78400.00	81804.00	160204.00
SILVER AND MEAL	76000.00	68970.00	144970.00
GROFF	75600.00	68765.00	144365.00
- - VECTOR 87 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	81600.00	94100.00	175700.00
SILVER AND MEAL	84400.00	77409.00	161809.00
GROFF	85600.00	76015.00	161615.00
- - VECTOR 88 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	79600.00	92275.00	171875.00
SILVER AND MEAL	80400.00	73867.00	154267.00
GROFF	80400.00	72953.00	153353.00
- - VECTOR 89 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	77600.00	85402.00	163002.00
SILVER AND MEAL	79200.00	69228.00	148428.00
GROFF	78800.00	69093.00	147893.00
- - VECTOR 90 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	77200.00	90007.00	167207.00
SILVER AND MEAL	77200.00	74364.00	151564.00
GROFF	76400.00	74680.00	151080.00

- - VECTOR 1 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	199423.00	499548.00
SILVER AND MEAL	249704.00	228609.00	478313.00
GROFF	244902.00	234663.00	479565.00
- - VECTOR 2 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	198970.00	499095.00
SILVER AND MEAL	252105.00	223024.00	475129.00
GROFF	244902.00	229894.00	474796.00
- - VECTOR 3 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	200815.00	500940.00
SILVER AND MEAL	242501.00	239755.00	482256.00
GROFF	237699.00	244194.00	481893.00
- - VECTOR 4 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	198924.00	499049.00
SILVER AND MEAL	240100.00	236833.00	476933.00
GROFF	242501.00	235914.00	478415.00
- - VECTOR 5 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	200969.00	501094.00
SILVER AND MEAL	247303.00	231858.00	479161.00
GROFF	242501.00	237962.00	480463.00
- - VECTOR 6 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	198691.00	498816.00
SILVER AND MEAL	244902.00	236099.00	481001.00
GROFF	240100.00	239039.00	479139.00
- - VECTOR 7 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	197647.00	497772.00
SILVER AND MEAL	247303.00	233535.00	480838.00
GROFF	244902.00	235824.00	480726.00
- - VECTOR 8 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	201844.00	501969.00
SILVER AND MEAL	244902.00	235667.00	480569.00
GROFF	247303.00	234174.00	481477.00
- - VECTOR 9 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	204093.00	504218.00
SILVER AND MEAL	249704.00	231762.00	481466.00
GROFF	247303.00	234852.00	482155.00
- - VECTOR 10 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	197672.00	497797.00
SILVER AND MEAL	244902.00	233012.00	477914.00
GROFF	244902.00	234892.00	479794.00
- - VECTOR 11 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	290521.00	207606.00	498127.00
SILVER AND MEAL	273714.00	188948.00	462662.00
GROFF	252105.00	204072.00	456177.00
- - VECTOR 12 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	266511.00	187090.00	453601.00
SILVER AND MEAL	271313.00	169912.00	441225.00
GROFF	252105.00	182178.00	434283.00
- - VECTOR 13 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	266511.00	203620.00	470131.00
SILVER AND MEAL	276115.00	182452.00	458567.00
GROFF	259308.00	198568.00	457876.00

- - VECTOR 14 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	292922.00	184074.00	476996.00
SILVER AND MEAL	273714.00	167034.00	440748.00
GROFF	244902.00	191293.00	436195.00
- - VECTOR 15 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	292922.00	171410.00	464332.00
SILVER AND MEAL	271313.00	166098.00	437411.00
GROFF	259308.00	179311.00	438619.00
- - VECTOR 16 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	285719.00	192308.00	478027.00
SILVER AND MEAL	268912.00	181504.00	450416.00
GROFF	252105.00	200717.00	452822.00
- - VECTOR 17 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	297724.00	182150.00	479874.00
SILVER AND MEAL	268912.00	163396.00	432308.00
GROFF	242501.00	185008.00	427509.00
- - VECTOR 18 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	268912.00	199678.00	468590.00
SILVER AND MEAL	280917.00	170187.00	451104.00
GROFF	256907.00	187739.00	444646.00
- - VECTOR 19 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	290521.00	192243.00	482764.00
SILVER AND MEAL	273714.00	174243.00	447957.00
GROFF	249704.00	193773.00	443477.00
- - VECTOR 20 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	288120.00	199587.00	487707.00
SILVER AND MEAL	266511.00	178049.00	444560.00
GROFF	249704.00	191522.00	441226.00
- - VECTOR 21 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	285719.00	151624.00	437343.00
SILVER AND MEAL	273714.00	120785.00	394499.00
GROFF	259308.00	130581.00	389889.00
- - VECTOR 22 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	290521.00	151710.00	442231.00
SILVER AND MEAL	290521.00	126766.00	417287.00
GROFF	261709.00	145520.00	407229.00
- - VECTOR 23 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	288120.00	167475.00	455595.00
SILVER AND MEAL	280917.00	129759.00	410676.00
GROFF	273714.00	136939.00	410653.00
- - VECTOR 24 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	283318.00	167169.00	450487.00
SILVER AND MEAL	283318.00	139620.00	422938.00
GROFF	268912.00	150645.00	419557.00
- - VECTOR 25 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	280917.00	133905.00	414822.00
SILVER AND MEAL	276115.00	119509.00	395624.00
GROFF	264110.00	128039.00	392149.00
- - VECTOR 26 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	285719.00	158143.00	443862.00
SILVER AND MEAL	271313.00	136845.00	408158.00
GROFF	259308.00	146337.00	405645.00

- - VECTOR 27 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	288120.00	163329.00	451449.00
SILVER AND MEAL	280917.00	121388.00	402305.00
GROFF	276115.00	127439.00	403554.00
- - VECTOR 28 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	268912.00	146313.00	415225.00
SILVER AND MEAL	261709.00	135069.00	396778.00
GROFF	252105.00	143571.00	395676.00
- - VECTOR 29 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	290521.00	136356.00	426877.00
SILVER AND MEAL	273714.00	107178.00	380892.00
GROFF	261709.00	116243.00	377952.00
- - VECTOR 30 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	278516.00	168499.00	447015.00
SILVER AND MEAL	283318.00	137650.00	420968.00
GROFF	271313.00	145800.00	417113.00
- - VECTOR 31 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	194712.00	494837.00
SILVER AND MEAL	252105.00	227626.00	479731.00
GROFF	244902.00	233990.00	478892.00
- - VECTOR 32 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	202616.00	502741.00
SILVER AND MEAL	244902.00	239544.00	484446.00
GROFF	244902.00	238329.00	483231.00
- - VECTOR 33 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	205368.00	505493.00
SILVER AND MEAL	249704.00	235149.00	484853.00
GROFF	247303.00	236573.00	483876.00
- - VECTOR 34 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	201221.00	501346.00
SILVER AND MEAL	249704.00	230915.00	480619.00
GROFF	237699.00	242730.00	480429.00
- - VECTOR 35 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	197852.00	497977.00
SILVER AND MEAL	244902.00	234156.00	479058.00
GROFF	244902.00	234732.00	479634.00
- - VECTOR 36 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	199048.00	499173.00
SILVER AND MEAL	256907.00	224528.00	481435.00
GROFF	244902.00	238626.00	483528.00
- - VECTOR 37 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	201364.00	501489.00
SILVER AND MEAL	249704.00	234760.00	484464.00
GROFF	242501.00	239205.00	481706.00
- - VECTOR 38 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	204347.00	504472.00
SILVER AND MEAL	249704.00	239098.00	488802.00
GROFF	244902.00	242534.00	487436.00
- - VECTOR 39 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	196272.00	496397.00
SILVER AND MEAL	254506.00	223666.00	478172.00
GROFF	247303.00	231112.00	478415.00

- - VECTOR 40 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	197609.00	497734.00
SILVER AND MEAL	240100.00	241419.00	481519.00
GROFF	242501.00	240499.00	483000.00
- - VECTOR 41 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	264110.00	192030.00	456140.00
SILVER AND MEAL	273714.00	169992.00	443706.00
GROFF	247303.00	188502.00	435805.00
- - VECTOR 42 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	261709.00	190411.00	452120.00
SILVER AND MEAL	256907.00	179095.00	436002.00
GROFF	247303.00	184357.00	431660.00
- - VECTOR 43 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	276115.00	199485.00	475600.00
SILVER AND MEAL	271313.00	179427.00	450740.00
GROFF	252105.00	192715.00	444820.00
- - VECTOR 44 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	288120.00	190649.00	478769.00
SILVER AND MEAL	264110.00	186049.00	450159.00
GROFF	254506.00	195091.00	449597.00
- - VECTOR 45 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	288120.00	204299.00	492419.00
SILVER AND MEAL	271313.00	193845.00	465158.00
GROFF	261709.00	204622.00	466331.00
- - VECTOR 46 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	268912.00	194137.00	463049.00
SILVER AND MEAL	268912.00	178643.00	447555.00
GROFF	256907.00	187015.00	443922.00
- - VECTOR 47 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	259308.00	186699.00	446007.00
SILVER AND MEAL	268912.00	166148.00	435060.00
GROFF	242501.00	187459.00	429960.00
- - VECTOR 48 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	283318.00	189897.00	473215.00
SILVER AND MEAL	276115.00	174906.00	451021.00
GROFF	259308.00	190096.00	449404.00
- - VECTOR 49 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	271313.00	186477.00	457790.00
SILVER AND MEAL	261709.00	176055.00	437764.00
GROFF	244902.00	192993.00	437895.00
- - VECTOR 50 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	288120.00	201119.00	489239.00
SILVER AND MEAL	254506.00	202378.00	456884.00
GROFF	247303.00	210928.00	458231.00
- - VECTOR 51 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	283318.00	170896.00	454214.00
SILVER AND MEAL	280917.00	141012.00	421929.00
GROFF	268912.00	153899.00	422811.00
- - VECTOR 52 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	290521.00	151365.00	441886.00
SILVER AND MEAL	280917.00	119651.00	400568.00
GROFF	256907.00	137839.00	394746.00

- - VECTOR 53 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	288120.00	140418.00	428538.00
SILVER AND MEAL	268912.00	119078.00	387990.00
GROFF	254506.00	133816.00	388322.00
- - VECTOR 54 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	271313.00	161294.00	432607.00
SILVER AND MEAL	276115.00	141784.00	417899.00
GROFF	271313.00	148890.00	420203.00
- - VECTOR 55 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	288120.00	155096.00	443216.00
SILVER AND MEAL	280917.00	123635.00	404552.00
GROFF	264110.00	139259.00	403369.00
- - VECTOR 56 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	285719.00	142525.00	428244.00
SILVER AND MEAL	276115.00	122266.00	398381.00
GROFF	259308.00	136274.00	395582.00
- - VECTOR 57 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	285719.00	150607.00	436326.00
SILVER AND MEAL	276115.00	122477.00	398592.00
GROFF	256907.00	134275.00	391182.00
- - VECTOR 58 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	283318.00	172373.00	455691.00
SILVER AND MEAL	283318.00	127931.00	411249.00
GROFF	259308.00	146723.00	406031.00
- - VECTOR 59 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	285719.00	153973.00	439692.00
SILVER AND MEAL	278516.00	120662.00	399178.00
GROFF	259308.00	136812.00	396120.00
- - VECTOR 60 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	288120.00	151559.00	439679.00
SILVER AND MEAL	280917.00	130541.00	411458.00
GROFF	259308.00	145771.00	405079.00
- - VECTOR 61 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	300125.00	194688.00	494813.00
SILVER AND MEAL	252105.00	227626.00	479731.00
GROFF	244902.00	233990.00	478892.00
- - VECTOR 62 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	300125.00	202616.00	502741.00
SILVER AND MEAL	244902.00	239544.00	484446.00
GROFF	244902.00	238329.00	483231.00
- - VECTOR 63 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	300125.00	205368.00	505493.00
SILVER AND MEAL	249704.00	235149.00	484853.00
GROFF	247303.00	236573.00	483876.00
- - VECTOR 64 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	300125.00	201221.00	501346.00
SILVER AND MEAL	249704.00	230915.00	480619.00
GROFF	237699.00	242730.00	480429.00
- - VECTOR 65 - - TYPE 1 GROUPING - -			
PERIODIC ORDER	300125.00	197666.00	497791.00
SILVER AND MEAL	244902.00	233970.00	478872.00
GROFF	244902.00	234742.00	479644.00

- - VECTOR 66 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	199048.00	499173.00
SILVER AND MEAL	256907.00	224528.00	481435.00
GROFF	244902.00	238626.00	483528.00
- - VECTOR 67 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	201364.00	501489.00
SILVER AND MEAL	249704.00	234760.00	484464.00
GROFF	242501.00	239205.00	481706.00
- - VECTOR 68 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	204347.00	504472.00
SILVER AND MEAL	249704.00	239098.00	488802.00
GROFF	244902.00	242534.00	487436.00
- - VECTOR 69 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	196272.00	496397.00
SILVER AND MEAL	254506.00	223666.00	478172.00
GROFF	247303.00	231112.00	478415.00
- - VECTOR 70 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	300125.00	197609.00	497734.00
SILVER AND MEAL	240100.00	241419.00	481519.00
GROFF	242501.00	240499.00	483000.00
- - VECTOR 71 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	264110.00	207900.00	472010.00
SILVER AND MEAL	264110.00	183026.00	447136.00
GROFF	242501.00	201313.00	443814.00
- - VECTOR 72 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	295323.00	190293.00	485616.00
SILVER AND MEAL	266511.00	173804.00	440315.00
GROFF	247303.00	195445.00	442748.00
- - VECTOR 73 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	290521.00	194197.00	484718.00
SILVER AND MEAL	261709.00	181508.00	443217.00
GROFF	247303.00	194590.00	441893.00
- - VECTOR 74 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	280917.00	206008.00	486925.00
SILVER AND MEAL	271313.00	184471.00	455784.00
GROFF	261709.00	193531.00	455240.00
- - VECTOR 75 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	292922.00	190652.00	483574.00
SILVER AND MEAL	256907.00	175751.00	432658.00
GROFF	242501.00	187174.00	429675.00
- - VECTOR 76 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	288120.00	192611.00	480731.00
SILVER AND MEAL	264110.00	183514.00	447624.00
GROFF	249704.00	195891.00	445595.00
- - VECTOR 77 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	290521.00	193719.00	484240.00
SILVER AND MEAL	264110.00	182169.00	446279.00
GROFF	244902.00	196752.00	441654.00
- - VECTOR 78 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	283318.00	196172.00	479490.00
SILVER AND MEAL	261709.00	196419.00	458128.00
GROFF	256907.00	198027.00	454934.00

- - VECTOR 79 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	292922.00	209685.00	502607.00
SILVER AND MEAL	271313.00	186124.00	457437.00
GROFF	252105.00	200171.00	452276.00
- - VECTOR 80 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	288120.00	188416.00	476536.00
SILVER AND MEAL	259308.00	176596.00	435904.00
GROFF	244902.00	187140.00	432042.00
- - VECTOR 81 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	283318.00	156609.00	439927.00
SILVER AND MEAL	280917.00	143469.00	424386.00
GROFF	266511.00	149011.00	415522.00
- - VECTOR 82 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	288120.00	149300.00	437420.00
SILVER AND MEAL	268912.00	133356.00	402268.00
GROFF	261709.00	140520.00	402229.00
- - VECTOR 83 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	285719.00	163648.00	449367.00
SILVER AND MEAL	278516.00	122788.00	401304.00
GROFF	264110.00	134389.00	398499.00
- - VECTOR 84 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	264110.00	153559.00	417669.00
SILVER AND MEAL	268912.00	136262.00	405174.00
GROFF	254506.00	147995.00	402501.00
- - VECTOR 85 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	288120.00	140314.00	428434.00
SILVER AND MEAL	271313.00	126412.00	397725.00
GROFF	254506.00	138381.00	392887.00
- - VECTOR 86 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	273714.00	141521.00	415235.00
SILVER AND MEAL	266511.00	125830.00	392341.00
GROFF	247303.00	143447.00	390750.00
- - VECTOR 87 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	278516.00	159626.00	438142.00
SILVER AND MEAL	276115.00	145617.00	421732.00
GROFF	261709.00	159737.00	421446.00
- - VECTOR 88 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	271313.00	149533.00	420846.00
SILVER AND MEAL	273714.00	138569.00	412283.00
GROFF	261709.00	148613.00	410322.00
- - VECTOR 89 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	283318.00	141240.00	424558.00
SILVER AND MEAL	271313.00	121378.00	392691.00
GROFF	259308.00	131809.00	391117.00
- - VECTOR 90 -	- TYPE 1 GROUPING - -		
PERIODIC ORDER	247303.00	163931.00	411234.00
SILVER AND MEAL	266511.00	134735.00	401246.00
GROFF	244902.00	149053.00	393955.00

- - VECTOR 1 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	199423.00	499548.00
SILVER AND MEAL	249704.00	228609.00	478313.00
GROFF	244902.00	234663.00	479565.00
- - VECTOR 2 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	198970.00	499095.00
SILVER AND MEAL	252105.00	223024.00	475129.00
GROFF	244902.00	229894.00	474796.00
- - VECTOR 3 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	200815.00	500940.00
SILVER AND MEAL	242501.00	239755.00	482256.00
GROFF	237699.00	244194.00	481893.00
- - VECTOR 4 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	198924.00	499049.00
SILVER AND MEAL	240100.00	236833.00	476933.00
GROFF	242501.00	235914.00	478415.00
- - VECTOR 5 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	200969.00	501094.00
SILVER AND MEAL	247303.00	231858.00	479161.00
GROFF	242501.00	237962.00	480463.00
- - VECTOR 6 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	198691.00	498816.00
SILVER AND MEAL	244902.00	236099.00	481001.00
GROFF	240100.00	239039.00	479139.00
- - VECTOR 7 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	197647.00	497772.00
SILVER AND MEAL	247303.00	233535.00	480838.00
GROFF	244902.00	235824.00	480726.00
- - VECTOR 8 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	201844.00	501969.00
SILVER AND MEAL	244902.00	235667.00	480569.00
GROFF	247303.00	234174.00	481477.00
- - VECTOR 9 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	204093.00	504218.00
SILVER AND MEAL	249704.00	231762.00	481466.00
GROFF	247303.00	234852.00	482155.00
- - VECTOR 10 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	197672.00	497797.00
SILVER AND MEAL	244902.00	233012.00	477914.00
GROFF	244902.00	234892.00	479794.00
- - VECTOR 11 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	283318.00	201646.00	484964.00
SILVER AND MEAL	268912.00	190374.00	459286.00
GROFF	254506.00	205060.00	459566.00
- - VECTOR 12 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	266511.00	196706.00	463217.00
SILVER AND MEAL	271313.00	167374.00	438687.00
GROFF	254506.00	182018.00	436524.00
- - VECTOR 13 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	271313.00	203820.00	475133.00
SILVER AND MEAL	268912.00	185896.00	454808.00
GROFF	254506.00	197450.00	451956.00

- - VECTOR 14 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	297724.00	187770.00	485494.00
SILVER AND MEAL	266511.00	171610.00	438121.00
GROFF	247303.00	187025.00	434328.00
- - VECTOR 15 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	295323.00	180326.00	475649.00
SILVER AND MEAL	254506.00	169130.00	423636.00
GROFF	244902.00	181983.00	426885.00
- - VECTOR 16 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	285719.00	197588.00	483307.00
SILVER AND MEAL	273714.00	181066.00	454780.00
GROFF	252105.00	198901.00	451006.00
- - VECTOR 17 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	290521.00	183198.00	473719.00
SILVER AND MEAL	264110.00	164460.00	428570.00
GROFF	247303.00	175292.00	422595.00
- - VECTOR 18 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	264110.00	199006.00	463116.00
SILVER AND MEAL	261709.00	182835.00	444544.00
GROFF	254506.00	190391.00	444897.00
- - VECTOR 19 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	278516.00	191719.00	470235.00
SILVER AND MEAL	266511.00	176269.00	442780.00
GROFF	254506.00	188567.00	443073.00
- - VECTOR 20 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	285719.00	197603.00	483322.00
SILVER AND MEAL	266511.00	179663.00	446174.00
GROFF	244902.00	196060.00	440962.00
- - VECTOR 21 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	244902.00	177698.00	422600.00
SILVER AND MEAL	242501.00	141763.00	384264.00
GROFF	230496.00	149085.00	379581.00
- - VECTOR 22 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	276115.00	166550.00	442665.00
SILVER AND MEAL	259308.00	134874.00	394182.00
GROFF	252105.00	139776.00	391881.00
- - VECTOR 23 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	290521.00	173909.00	464430.00
SILVER AND MEAL	264110.00	138939.00	403049.00
GROFF	252105.00	149029.00	401134.00
- - VECTOR 24 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	290521.00	192127.00	482648.00
SILVER AND MEAL	271313.00	142472.00	413785.00
GROFF	264110.00	150601.00	414711.00
- - VECTOR 25 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	278516.00	168909.00	447425.00
SILVER AND MEAL	249704.00	140341.00	390045.00
GROFF	244902.00	144381.00	389283.00
- - VECTOR 26 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	280917.00	181145.00	462062.00
SILVER AND MEAL	240100.00	157579.00	397679.00
GROFF	244902.00	154691.00	399593.00

- - VECTOR 27 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	273714.00	173997.00	447711.00
SILVER AND MEAL	249704.00	141076.00	390780.00
GROFF	242501.00	144609.00	387110.00
- - VECTOR 28 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	266511.00	159605.00	426116.00
SILVER AND MEAL	244902.00	145297.00	390199.00
GROFF	237699.00	149169.00	386868.00
- - VECTOR 29 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	201684.00	169420.00	371104.00
SILVER AND MEAL	230496.00	130988.00	361484.00
GROFF	223293.00	134817.00	358110.00
- - VECTOR 30 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	288120.00	182117.00	470237.00
SILVER AND MEAL	252105.00	155902.00	408007.00
GROFF	247303.00	157332.00	404635.00
- - VECTOR 31 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	194712.00	494837.00
SILVER AND MEAL	252105.00	227626.00	479731.00
GROFF	244902.00	233990.00	478892.00
- - VECTOR 32 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	202616.00	502741.00
SILVER AND MEAL	244902.00	239544.00	484446.00
GROFF	244902.00	238329.00	483231.00
- - VECTOR 33 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	205368.00	505493.00
SILVER AND MEAL	249704.00	235149.00	484853.00
GROFF	247303.00	236573.00	483876.00
- - VECTOR 34 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	201221.00	501346.00
SILVER AND MEAL	249704.00	230915.00	480619.00
GROFF	237699.00	242730.00	480429.00
- - VECTOR 35 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	197714.00	497839.00
SILVER AND MEAL	244902.00	233840.00	478742.00
GROFF	244902.00	235236.00	480138.00
- - VECTOR 36 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	199048.00	499173.00
SILVER AND MEAL	256907.00	224528.00	481435.00
GROFF	244902.00	238626.00	483528.00
- - VECTOR 37 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	201364.00	501489.00
SILVER AND MEAL	249704.00	234760.00	484464.00
GROFF	242501.00	239205.00	481706.00
- - VECTOR 38 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	204347.00	504472.00
SILVER AND MEAL	249704.00	239098.00	488802.00
GROFF	244902.00	242534.00	487436.00
- - VECTOR 39 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	196272.00	496397.00
SILVER AND MEAL	254506.00	223666.00	478172.00
GROFF	247303.00	231112.00	478415.00

- - VECTOR 40 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	197609.00	497734.00
SILVER AND MEAL	240100.00	241419.00	481519.00
GROFF	242501.00	240499.00	483000.00
- - VECTOR 41 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	268912.00	193718.00	462630.00
SILVER AND MEAL	256907.00	173014.00	429921.00
GROFF	237699.00	187942.00	425641.00
- - VECTOR 42 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	261709.00	185993.00	447702.00
SILVER AND MEAL	256907.00	172025.00	428932.00
GROFF	244902.00	183139.00	428041.00
- - VECTOR 43 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	268912.00	196953.00	465865.00
SILVER AND MEAL	249704.00	190031.00	439735.00
GROFF	235298.00	199041.00	434339.00
- - VECTOR 44 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	288120.00	178417.00	466537.00
SILVER AND MEAL	254506.00	188067.00	442573.00
GROFF	247303.00	193521.00	440824.00
- - VECTOR 45 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	285719.00	197509.00	483228.00
SILVER AND MEAL	264110.00	195834.00	459944.00
GROFF	261709.00	199670.00	461379.00
- - VECTOR 46 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	268912.00	197073.00	465985.00
SILVER AND MEAL	254506.00	183699.00	438205.00
GROFF	235298.00	197261.00	432559.00
- - VECTOR 47 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	254506.00	190065.00	444571.00
SILVER AND MEAL	247303.00	179992.00	427295.00
GROFF	240100.00	185941.00	426041.00
- - VECTOR 48 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	276115.00	179197.00	455312.00
SILVER AND MEAL	259308.00	179610.00	438918.00
GROFF	256907.00	187574.00	444481.00
- - VECTOR 49 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	261709.00	192425.00	454134.00
SILVER AND MEAL	256907.00	175357.00	432264.00
GROFF	242501.00	183857.00	426358.00
- - VECTOR 50 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	283318.00	191225.00	474543.00
SILVER AND MEAL	254506.00	201076.00	455582.00
GROFF	252105.00	203118.00	455223.00
- - VECTOR 51 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	292922.00	184226.00	477148.00
SILVER AND MEAL	252105.00	155288.00	407393.00
GROFF	252105.00	156409.00	408514.00
- - VECTOR 52 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	283318.00	156165.00	439483.00
SILVER AND MEAL	261709.00	126085.00	387794.00
GROFF	247303.00	134945.00	382248.00

- - VECTOR 53 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	264110.00	160750.00	424860.00
SILVER AND MEAL	242501.00	127974.00	370475.00
GROFF	232897.00	132248.00	365145.00
- - VECTOR 54 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	268912.00	177670.00	446582.00
SILVER AND MEAL	259308.00	156368.00	415676.00
GROFF	244902.00	165194.00	410096.00
- - VECTOR 55 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	285719.00	172700.00	458419.00
SILVER AND MEAL	247303.00	143813.00	391116.00
GROFF	237699.00	150535.00	388234.00
- - VECTOR 56 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	285719.00	164707.00	450426.00
SILVER AND MEAL	237699.00	146310.00	384009.00
GROFF	242501.00	145194.00	387695.00
- - VECTOR 57 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	278516.00	154959.00	433475.00
SILVER AND MEAL	247303.00	130639.00	377942.00
GROFF	230496.00	142181.00	372677.00
- - VECTOR 58 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	292922.00	175163.00	468085.00
SILVER AND MEAL	268912.00	132917.00	401829.00
GROFF	256907.00	143591.00	400498.00
- - VECTOR 59 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	280917.00	164341.00	445258.00
SILVER AND MEAL	254506.00	140448.00	394954.00
GROFF	240100.00	147024.00	387124.00
- - VECTOR 60 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	292922.00	172009.00	464931.00
SILVER AND MEAL	244902.00	143297.00	388199.00
GROFF	237699.00	149533.00	387232.00
- - VECTOR 61 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	194688.00	494813.00
SILVER AND MEAL	252105.00	227626.00	479731.00
GROFF	244902.00	233990.00	478892.00
- - VECTOR 62 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	202616.00	502741.00
SILVER AND MEAL	244902.00	239544.00	484446.00
GROFF	244902.00	238329.00	483231.00
- - VECTOR 63 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	205368.00	505493.00
SILVER AND MEAL	249704.00	235149.00	484853.00
GROFF	247303.00	236573.00	483876.00
- - VECTOR 64 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	201221.00	501346.00
SILVER AND MEAL	249704.00	230915.00	480619.00
GROFF	237699.00	242730.00	480429.00
- - VECTOR 65 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	197714.00	497839.00
SILVER AND MEAL	244902.00	233840.00	478742.00
GROFF	244902.00	235236.00	480138.00

- - VECTOR 66 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	199048.00	499173.00
SILVER AND MEAL	256907.00	224528.00	481435.00
GROFF	244902.00	238626.00	483528.00
- - VECTOR 67 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	201364.00	501489.00
SILVER AND MEAL	249704.00	234760.00	484464.00
GROFF	242501.00	239205.00	481706.00
- - VECTOR 68 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	204347.00	504472.00
SILVER AND MEAL	249704.00	239098.00	488802.00
GROFF	244902.00	242534.00	487436.00
- - VECTOR 69 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	196272.00	496397.00
SILVER AND MEAL	254506.00	223666.00	478172.00
GROFF	247303.00	231112.00	478415.00
- - VECTOR 70 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	300125.00	197609.00	497734.00
SILVER AND MEAL	240100.00	241419.00	481519.00
GROFF	242501.00	240499.00	483000.00
- - VECTOR 71 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	264110.00	210478.00	474588.00
SILVER AND MEAL	264110.00	187344.00	451454.00
GROFF	247303.00	199377.00	446680.00
- - VECTOR 72 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	276115.00	195797.00	471912.00
SILVER AND MEAL	254506.00	182711.00	437217.00
GROFF	232897.00	200341.00	433238.00
- - VECTOR 73 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	283318.00	195899.00	479217.00
SILVER AND MEAL	256907.00	180498.00	437405.00
GROFF	240100.00	192660.00	432760.00
- - VECTOR 74 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	273714.00	201630.00	475344.00
SILVER AND MEAL	259308.00	191405.00	450713.00
GROFF	247303.00	197561.00	444864.00
- - VECTOR 75 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	295323.00	184130.00	479453.00
SILVER AND MEAL	259308.00	175229.00	434537.00
GROFF	247303.00	185612.00	432915.00
- - VECTOR 76 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	290521.00	192231.00	482752.00
SILVER AND MEAL	264110.00	183472.00	447582.00
GROFF	252105.00	194635.00	446740.00
- - VECTOR 77 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	292922.00	195133.00	488055.00
SILVER AND MEAL	256907.00	190939.00	447846.00
GROFF	242501.00	198076.00	440577.00
- - VECTOR 78 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	285719.00	193500.00	479219.00
SILVER AND MEAL	266511.00	188297.00	454808.00
GROFF	254506.00	194071.00	448577.00

- - VECTOR 79 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	295323.00	200211.00	495534.00
SILVER AND MEAL	271313.00	189480.00	460793.00
GROFF	256907.00	196623.00	453530.00
- - VECTOR 80 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	288120.00	191408.00	479528.00
SILVER AND MEAL	261709.00	172566.00	434275.00
GROFF	244902.00	183620.00	428522.00
- - VECTOR 81 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	280917.00	171905.00	452822.00
SILVER AND MEAL	256907.00	160999.00	417906.00
GROFF	252105.00	166173.00	418278.00
- - VECTOR 82 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	288120.00	164716.00	452836.00
SILVER AND MEAL	254506.00	141766.00	396272.00
GROFF	228095.00	158872.00	386967.00
- - VECTOR 83 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	295323.00	165254.00	460577.00
SILVER AND MEAL	235298.00	141144.00	376442.00
GROFF	220892.00	152153.00	373045.00
- - VECTOR 84 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	264110.00	173105.00	437215.00
SILVER AND MEAL	247303.00	151840.00	399143.00
GROFF	242501.00	152739.00	395240.00
- - VECTOR 85 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	290521.00	160450.00	450971.00
SILVER AND MEAL	249704.00	131814.00	381518.00
GROFF	237699.00	140265.00	377964.00
- - VECTOR 86 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	271313.00	155045.00	426358.00
SILVER AND MEAL	249704.00	127540.00	377244.00
GROFF	240100.00	135437.00	375537.00
- - VECTOR 87 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	283318.00	172242.00	455560.00
SILVER AND MEAL	249704.00	156825.00	406529.00
GROFF	247303.00	157793.00	405096.00
- - VECTOR 88 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	271313.00	171897.00	443210.00
SILVER AND MEAL	249704.00	148329.00	398033.00
GROFF	242501.00	154933.00	397434.00
- - VECTOR 89 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	285719.00	153920.00	439639.00
SILVER AND MEAL	249704.00	134206.00	383910.00
GROFF	240100.00	143109.00	383209.00
- - VECTOR 90 -	- TYPE 2 GROUPING - -		
PERIODIC ORDER	244902.00	170433.00	415335.00
SILVER AND MEAL	228095.00	151795.00	379890.00
GROFF	223293.00	152469.00	375762.00

- - VECTOR 1 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	199423.00	499548.00
SILVER AND MEAL	249704.00	228609.00	478313.00
GROFF	244902.00	234663.00	479565.00
- - VECTOR 2 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	198970.00	499095.00
SILVER AND MEAL	252105.00	223024.00	475129.00
GROFF	244902.00	229894.00	474796.00
- - VECTOR 3 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	200815.00	500940.00
SILVER AND MEAL	242501.00	239755.00	482256.00
GROFF	237699.00	244194.00	481893.00
- - VECTOR 4 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	198924.00	499049.00
SILVER AND MEAL	240100.00	236833.00	476933.00
GROFF	242501.00	235914.00	478415.00
- - VECTOR 5 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	200969.00	501094.00
SILVER AND MEAL	247303.00	231858.00	479161.00
GROFF	242501.00	237962.00	480463.00
- - VECTOR 6 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	198691.00	498816.00
SILVER AND MEAL	244902.00	236099.00	481001.00
GROFF	240100.00	239039.00	479139.00
- - VECTOR 7 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	197647.00	497772.00
SILVER AND MEAL	247303.00	233535.00	480838.00
GROFF	244902.00	235824.00	480726.00
- - VECTOR 8 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	201844.00	501969.00
SILVER AND MEAL	244902.00	235667.00	480569.00
GROFF	247303.00	234174.00	481477.00
- - VECTOR 9 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	204093.00	504218.00
SILVER AND MEAL	249704.00	231762.00	481466.00
GROFF	247303.00	234852.00	482155.00
- - VECTOR 10 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	197672.00	497797.00
SILVER AND MEAL	244902.00	233012.00	477914.00
GROFF	244902.00	234892.00	479794.00
- - VECTOR 11 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	292922.00	199220.00	492142.00
SILVER AND MEAL	271313.00	189714.00	461027.00
GROFF	261709.00	196080.00	457789.00
- - VECTOR 12 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	292922.00	186986.00	479908.00
SILVER AND MEAL	271313.00	168224.00	439537.00
GROFF	259308.00	176872.00	436180.00
- - VECTOR 13 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	290521.00	202938.00	493459.00
SILVER AND MEAL	280917.00	181056.00	461973.00
GROFF	264110.00	193826.00	457936.00

- - VECTOR 14 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	290521.00	191780.00	482301.00
SILVER AND MEAL	271313.00	169550.00	440863.00
GROFF	247303.00	188401.00	435704.00
- - VECTOR 15 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	288120.00	178578.00	466698.00
SILVER AND MEAL	278516.00	163836.00	442352.00
GROFF	252105.00	183231.00	435336.00
- - VECTOR 16 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	292922.00	205072.00	497994.00
SILVER AND MEAL	268912.00	187724.00	456636.00
GROFF	256907.00	198411.00	455318.00
- - VECTOR 17 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	288120.00	184282.00	472402.00
SILVER AND MEAL	278516.00	162474.00	440990.00
GROFF	242501.00	185658.00	428159.00
- - VECTOR 18 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	288120.00	197466.00	485586.00
SILVER AND MEAL	276115.00	176315.00	452430.00
GROFF	261709.00	189191.00	450900.00
- - VECTOR 19 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	288120.00	196419.00	484539.00
SILVER AND MEAL	268912.00	185225.00	454137.00
GROFF	254506.00	194403.00	448909.00
- - VECTOR 20 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	290521.00	192089.00	482610.00
SILVER AND MEAL	252105.00	187199.00	439304.00
GROFF	242501.00	193198.00	435699.00
- - VECTOR 21 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	254506.00	174490.00	428996.00
SILVER AND MEAL	261709.00	136473.00	398182.00
GROFF	249704.00	142907.00	392611.00
- - VECTOR 22 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	259308.00	175652.00	434960.00
SILVER AND MEAL	283318.00	127834.00	411152.00
GROFF	259308.00	145688.00	404996.00
- - VECTOR 23 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	266511.00	180983.00	447494.00
SILVER AND MEAL	276115.00	140767.00	416882.00
GROFF	256907.00	149977.00	406884.00
- - VECTOR 24 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	268912.00	195173.00	464085.00
SILVER AND MEAL	283318.00	147646.00	430964.00
GROFF	271313.00	153147.00	424460.00
- - VECTOR 25 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	244902.00	173317.00	418219.00
SILVER AND MEAL	278516.00	132501.00	411017.00
GROFF	261709.00	142801.00	404510.00
- - VECTOR 26 - - ORIGINAL GROUPING - -			
PERIODIC ORDER	264110.00	181649.00	445759.00
SILVER AND MEAL	264110.00	148629.00	412739.00
GROFF	252105.00	157295.00	409400.00

- - VECTOR 27 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	261709.00	166049.00	427758.00
SILVER AND MEAL	273714.00	134018.00	407732.00
GROFF	261709.00	142807.00	404516.00
- - VECTOR 28 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	261709.00	184801.00	446510.00
SILVER AND MEAL	271313.00	134835.00	406148.00
GROFF	266511.00	143901.00	410412.00
- - VECTOR 29 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	247303.00	157658.00	404961.00
SILVER AND MEAL	264110.00	125264.00	389374.00
GROFF	237699.00	137013.00	374712.00
- - VECTOR 30 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	261709.00	190981.00	452690.00
SILVER AND MEAL	278516.00	144310.00	422826.00
GROFF	266511.00	152004.00	418515.00
- - VECTOR 31 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	194712.00	494837.00
SILVER AND MEAL	252105.00	227626.00	479731.00
GROFF	244902.00	233990.00	478892.00
- - VECTOR 32 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	202616.00	502741.00
SILVER AND MEAL	244902.00	239544.00	484446.00
GROFF	244902.00	238329.00	483231.00
- - VECTOR 33 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	205368.00	505493.00
SILVER AND MEAL	249704.00	235149.00	484853.00
GROFF	247303.00	236573.00	483876.00
- - VECTOR 34 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	201221.00	501346.00
SILVER AND MEAL	249704.00	230915.00	480619.00
GROFF	237699.00	242730.00	480429.00
- - VECTOR 35 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	198572.00	498697.00
SILVER AND MEAL	244902.00	233759.00	478661.00
GROFF	244902.00	235054.00	479956.00
- - VECTOR 36 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	199048.00	499173.00
SILVER AND MEAL	256907.00	224528.00	481435.00
GROFF	244902.00	238626.00	483528.00
- - VECTOR 37 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	201364.00	501489.00
SILVER AND MEAL	249704.00	234760.00	484464.00
GROFF	242501.00	239205.00	481706.00
- - VECTOR 38 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	204347.00	504472.00
SILVER AND MEAL	249704.00	239098.00	488802.00
GROFF	244902.00	242534.00	487436.00
- - VECTOR 39 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	196272.00	496397.00
SILVER AND MEAL	254506.00	223666.00	478172.00
GROFF	247303.00	231112.00	478415.00

- - VECTOR 40 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	197609.00	497734.00
SILVER AND MEAL	240100.00	241419.00	481519.00
GROFF	242501.00	240499.00	483000.00
- - VECTOR 41 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	280917.00	181018.00	461935.00
SILVER AND MEAL	266511.00	175754.00	442265.00
GROFF	256907.00	183598.00	440505.00
- - VECTOR 42 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	283318.00	188279.00	471597.00
SILVER AND MEAL	266511.00	172997.00	439508.00
GROFF	254506.00	182487.00	436993.00
- - VECTOR 43 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	280917.00	191619.00	472536.00
SILVER AND MEAL	273714.00	181755.00	455469.00
GROFF	254506.00	197193.00	451699.00
- - VECTOR 44 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	283318.00	185751.00	469069.00
SILVER AND MEAL	271313.00	183881.00	455194.00
GROFF	252105.00	198775.00	450880.00
- - VECTOR 45 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	285719.00	207263.00	492982.00
SILVER AND MEAL	283318.00	183776.00	467094.00
GROFF	264110.00	201118.00	465228.00
- - VECTOR 46 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	283318.00	195973.00	479291.00
SILVER AND MEAL	268912.00	181303.00	450215.00
GROFF	252105.00	197423.00	449528.00
- - VECTOR 47 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	283318.00	181771.00	465089.00
SILVER AND MEAL	266511.00	178666.00	445177.00
GROFF	252105.00	189177.00	441282.00
- - VECTOR 48 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	283318.00	190467.00	473785.00
SILVER AND MEAL	278516.00	174398.00	452914.00
GROFF	259308.00	191182.00	450490.00
- - VECTOR 49 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	285719.00	188075.00	473794.00
SILVER AND MEAL	264110.00	176539.00	440649.00
GROFF	249704.00	192575.00	442279.00
- - VECTOR 50 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	283318.00	198907.00	482225.00
SILVER AND MEAL	278516.00	186524.00	465040.00
GROFF	259308.00	200652.00	459960.00
- - VECTOR 51 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	256907.00	204170.00	461077.00
SILVER AND MEAL	278516.00	148226.00	426742.00
GROFF	264110.00	158349.00	422459.00
- - VECTOR 52 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	256907.00	176625.00	433532.00
SILVER AND MEAL	264110.00	130023.00	394133.00
GROFF	242501.00	143061.00	385562.00

- - VECTOR 53 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	264110.00	161640.00	425750.00
SILVER AND MEAL	261709.00	126154.00	387863.00
GROFF	242501.00	136974.00	379475.00
- - VECTOR 54 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	261709.00	196256.00	457965.00
SILVER AND MEAL	288120.00	147508.00	435628.00
GROFF	266511.00	161628.00	428139.00
- - VECTOR 55 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	261709.00	178144.00	439853.00
SILVER AND MEAL	268912.00	136365.00	405277.00
GROFF	249704.00	150937.00	400641.00
- - VECTOR 56 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	259308.00	174521.00	433829.00
SILVER AND MEAL	273714.00	122666.00	396380.00
GROFF	249704.00	138730.00	388434.00
- - VECTOR 57 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	256907.00	176861.00	433768.00
SILVER AND MEAL	259308.00	139995.00	399303.00
GROFF	230496.00	154561.00	385057.00
- - VECTOR 58 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	261709.00	177763.00	439472.00
SILVER AND MEAL	276115.00	140531.00	416646.00
GROFF	249704.00	153947.00	403651.00
- - VECTOR 59 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	259308.00	175821.00	435129.00
SILVER AND MEAL	273714.00	128452.00	402166.00
GROFF	252105.00	143594.00	395699.00
- - VECTOR 60 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	264110.00	182283.00	446393.00
SILVER AND MEAL	288120.00	129363.00	417483.00
GROFF	256907.00	145647.00	402554.00
- - VECTOR 61 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	194688.00	494813.00
SILVER AND MEAL	252105.00	227626.00	479731.00
GROFF	244902.00	233990.00	478892.00
- - VECTOR 62 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	202616.00	502741.00
SILVER AND MEAL	244902.00	239544.00	484446.00
GROFF	244902.00	238329.00	483231.00
- - VECTOR 63 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	205368.00	505493.00
SILVER AND MEAL	249704.00	235149.00	484853.00
GROFF	247303.00	236573.00	483876.00
- - VECTOR 64 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	201221.00	501346.00
SILVER AND MEAL	249704.00	230915.00	480619.00
GROFF	237699.00	242730.00	480429.00
- - VECTOR 65 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	198572.00	498697.00
SILVER AND MEAL	244902.00	233759.00	478661.00
GROFF	244902.00	235054.00	479956.00

- - VECTOR 66 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	199048.00	499173.00
SILVER AND MEAL	256907.00	224528.00	481435.00
GROFF	244902.00	238626.00	483528.00
- - VECTOR 67 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	201364.00	501489.00
SILVER AND MEAL	249704.00	234760.00	484464.00
GROFF	242501.00	239205.00	481706.00
- - VECTOR 68 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	204347.00	504472.00
SILVER AND MEAL	249704.00	239098.00	488802.00
GROFF	244902.00	242534.00	487436.00
- - VECTOR 69 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	196272.00	496397.00
SILVER AND MEAL	254506.00	223666.00	478172.00
GROFF	247303.00	231112.00	478415.00
- - VECTOR 70 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	300125.00	197609.00	497734.00
SILVER AND MEAL	240100.00	241419.00	481519.00
GROFF	242501.00	240499.00	483000.00
- - VECTOR 71 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	292922.00	196962.00	489884.00
SILVER AND MEAL	268912.00	181663.00	450575.00
GROFF	249704.00	197253.00	446957.00
- - VECTOR 72 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	288120.00	190097.00	478217.00
SILVER AND MEAL	266511.00	180203.00	446714.00
GROFF	249704.00	192883.00	442587.00
- - VECTOR 73 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	288120.00	197725.00	485845.00
SILVER AND MEAL	256907.00	184066.00	440973.00
GROFF	235298.00	203140.00	438438.00
- - VECTOR 74 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	290521.00	200188.00	490709.00
SILVER AND MEAL	261709.00	189925.00	451634.00
GROFF	252105.00	196339.00	448444.00
- - VECTOR 75 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	290521.00	183366.00	473887.00
SILVER AND MEAL	264110.00	174403.00	438513.00
GROFF	249704.00	185816.00	435520.00
- - VECTOR 76 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	288120.00	204669.00	492789.00
SILVER AND MEAL	268912.00	182644.00	451556.00
GROFF	256907.00	193509.00	450416.00
- - VECTOR 77 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	290521.00	194503.00	485024.00
SILVER AND MEAL	259308.00	187031.00	446339.00
GROFF	249704.00	198478.00	448182.00
- - VECTOR 78 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	295323.00	202570.00	497893.00
SILVER AND MEAL	261709.00	190295.00	452004.00
GROFF	244902.00	204335.00	449237.00

- - VECTOR 79 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	288120.00	203619.00	491739.00
SILVER AND MEAL	266511.00	194854.00	461365.00
GROFF	247303.00	209727.00	457030.00
- - VECTOR 80 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	288120.00	177256.00	465376.00
SILVER AND MEAL	271313.00	167722.00	439035.00
GROFF	249704.00	186524.00	436228.00
- - VECTOR 81 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	264110.00	188767.00	452877.00
SILVER AND MEAL	273714.00	152135.00	425849.00
GROFF	252105.00	163313.00	415418.00
- - VECTOR 82 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	259308.00	181438.00	440746.00
SILVER AND MEAL	261709.00	141256.00	402965.00
GROFF	247303.00	154434.00	401737.00
- - VECTOR 83 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	264110.00	170140.00	434250.00
SILVER AND MEAL	259308.00	132922.00	392230.00
GROFF	242501.00	144139.00	386640.00
- - VECTOR 84 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	264110.00	195695.00	459805.00
SILVER AND MEAL	271313.00	147240.00	418553.00
GROFF	249704.00	160735.00	410439.00
- - VECTOR 85 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	259308.00	168200.00	427508.00
SILVER AND MEAL	254506.00	138162.00	392668.00
GROFF	244902.00	144771.00	389673.00
- - VECTOR 86 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	264110.00	166271.00	430381.00
SILVER AND MEAL	271313.00	125164.00	396477.00
GROFF	249704.00	143605.00	393309.00
- - VECTOR 87 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	268912.00	192944.00	461856.00
SILVER AND MEAL	266511.00	158759.00	425270.00
GROFF	247303.00	172767.00	420070.00
- - VECTOR 88 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	271313.00	179151.00	450464.00
SILVER AND MEAL	264110.00	144837.00	408947.00
GROFF	249704.00	153565.00	403269.00
- - VECTOR 89 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	264110.00	169142.00	433252.00
SILVER AND MEAL	273714.00	131694.00	405408.00
GROFF	242501.00	149875.00	392376.00
- - VECTOR 90 -	- ORIGINAL GROUPING - -		
PERIODIC ORDER	261709.00	182203.00	443912.00
SILVER AND MEAL	261709.00	144217.00	405926.00
GROFF	240100.00	157361.00	397461.00

APPENDIX F

A Measure of Periodicity

In Chapter II we defined groupiness as an element of lumpiness. In Chapter IV we developed a method of altering requirements vectors to incorporate grouping patterns. We now suggest a method of measuring the grouping of a requirements vector in terms of the interspersion of periods with positive requirements with periods of no requirements. At this level of consideration, a vector of requirements may be represented as a sequence of 1's and 0's for occurrence and non-occurrence (null) periods respectively.

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	period													
	1	2	3	4	5	6	7	8	9	10	11	12	w	frequency
'A'	1	1	1	1	1	1	1	1	1	1	1	1	0.000	12
'B'	1	1	1	1	1	0	1	1	1	1	1	1	0.017	11
'C'	1	1	1	1	1	1	1	1	0	0	0	0	0.063	8
'D'	1	1	1	1	1	1	1	0	0	0	0	1	0.083	8
'E'	1	1	1	1	1	1	0	0	0	0	1	1	0.108	8
'F'	1	1	1	1	0	0	0	0	1	1	1	1	0.125	8
'G'	1	1	0	1	1	0	1	1	0	1	1	0	0.250	8
'H'	1	1	0	0	1	1	0	0	1	1	0	0	0.500	6
'I'	1	0	1	0	1	0	1	0	1	0	1	0	1.000	6

Figure A.1 -- Characterization of Requirements Vector as Periods of Null and Positive Requirements.

The Vectors illustrated in Figure A.1, depict a "0", "1" representation of requirements. To measure the grouping pattern, we consider the length of each sequence of 0's and 1's, and the relative frequency of positive occurrences. A

"run length" is defined as the number of consecutive periods with the same type occurrence. A positive run length of five periods indicates five consecutive periods in which a requirement occurred.

The expected null length (EL) is the ratio of null periods to positive requirement periods and is independent of the particular grouping pattern of a requirements vector. It is a measure of the limiting null interval between positive occurrence periods. As a measure of the relationship of null sequences to positive sequences, we define w as a measure of periodicity of requirements vectors that have a relative frequency of positive requirements greater than or equal to 0.50.

$$w = \frac{EL}{(MP) \ / \ GMP} \qquad (A.2)$$

where :

EL = Expected null length, ratio of null periods to positive periods.** (EL < 1.0)

MP = Arithmetic mean positive run length

GMP = Geometic mean positive run length

$$0 < w < 1 \qquad (A.3)$$

** The expected null length may also be computed as (1/relative frequency of positive periods) -1.

Figure 4.16 presents the value of w for requirements vectors with dissimilar grouping patterns and frequencies of positive requirements. Given two vectors with the same expected null and average positive run length, the vector with the greater variation in positive run length will have the smaller value of w. Given two vectors with the same mean value and variation of positive run length, the vector with the smaller expected null length will have the smaller value of w.

VITA

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